2009

Vision 2009

VISION

The University of Montana

Research & Innovation 2009

The Limits of Human Endurance

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Cover: Jeff Cincoski, a triathlete and UM employee, puts a research bike through its paces in a 100-degree, temperature-controlled room at the Montana Center for Work Physiology and Exercise Metabolism.

A lone runner seeks his personal physical limits during the 135-mile Badwater Ultramarathon in Death Valley, Calif. UM researchers were there to quantify the results.
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Inner Vision

Message From The Vice President

In my role as vice president for research and development at The University of Montana, I'm constantly amazed by the sheer breadth of scientific and academic inquiry taking place at this institution. Here in Western Montana, we are involved with bees sniffing out land mines, a NASA spacecraft mapping the edge of the solar system and the discovery of a drug that diminishes stroke damage in an animal model. The list of special projects goes on, revealing UM's growing importance as a research institution.

Campus projects now expend more than $67 million annually. Most funding comes from federal granting agencies such as the National Science Foundation, the National Institutes of Health and the U.S. Department of Energy, to name just a few. This funding generates jobs that have become an important component of the local and state economies. They also finance laboratories that, in addition to doing outstanding science, become important, hands-on places of learning for UM undergraduate and graduate students. Our research endeavors allow us to train the next generation of scientists beyond the classroom.

With campus brimming with ideas that push the frontiers of knowledge, it's my pleasure to share a few of them with you in this issue of Vision, our annual research magazine.

The cover story features research Professor Brent Ruby and his Montana Center for Work Physiology and Exercise Metabolism. Working either in a recent addition to McGill Hall or in a mobile laboratory Airstream trailer, Ruby and his team are searching for the outer limit of energy expenditure among human beings. This quest recently took them to California's 135-mile Badwater Ultramarathon and ultimately may improve safety and performance for extreme athletes, firefighters and U.S. troops.

Other stories in this issue involve pressing environmental issues. There is the movement of contaminated sediment after the historic removal of Milltown Dam upstream from Missoula and the fact that decades of vermiculite mining near Libby have laced the surrounding trees with hazardous asbestos.

Another article examines groundbreaking UM work to unearth an ancient "housepit" village in British Columbia, while another highlights work by a faculty member to develop an improved form of electronic note-taking. One story reveals how moose had to relearn their fear of wolves when the predators were reintroduced to Yellowstone, and another feature describes a UM law professor's work to reveal the original intent of the Constitution using other documents that were contemporary to the Founding Fathers.

The sheer variety of research and scholarship being conducted at the University never fails to amaze. It makes it all the more appropriate that UM will host two of the nation's premier scientific conferences in 2010 – the National Conference on Undergraduate Research in April and the Society of Environmental Journalists Annual Conference in October.

UM research has generated hundreds of stories begging to be told. We hope you enjoy this glimpse into a few of these efforts. V

Daniel J. Dwyer
Vice President for Research and Development
The University of Montana

University scientists rack up record funding

UM researchers expended more than $67 million from external grants and contracts to support UM's research enterprise in fiscal year 2009. Daniel Dwyer, UM vice president for research and development, says that the total is an institutional record that reflects an 8 percent growth rate from last year's expenditures.

The top five new award recipients were:

- **Andrij Holian, Center for Environmental Health Sciences, $2.9 million.**
- **Rick Hauer, Flathead Lake Biological Station, $2.8 million.**
- **Michael Kavanaugh, Center for Structural and Functional Neuroscience, $2.3 million.**
- **Tom Seekins, Research and Training Center on Disability in Rural Communities, $2.2 million.**
- **Bernadette Bannister, Continuing Education, $1.6 million.**

UM President George M. Dennison says the funds attracted by campus researchers contribute significantly to economic development in Montana, support graduate science students and keep UM faculty and researchers on the cutting edge of research and development. V

Rising science stars capture prestigious grants

Scientists recently scored big for UM research by earning three prestigious Early Career Development Program grants from the National Science Foundation.

This is the second consecutive year that multiple UM researchers have earned the five-year awards. The latest honors went to assistant professors **Klara Briknarova** in the Department of Chemistry and Biochemistry, **Lila Fishman** in the Division of Biological Sciences and **Art Woods** in the Division of Biological Sciences.

Each year between 350 and 400 assistant professors nationally earn CAREER grants, which honor promising teacher-scholars who most effectively integrate research and education for their institution.

A handful of UM researchers have earned the awards in the past, but last year was the first time the University had two awardees in the same year. Last year's winners were biology assistant professors **Vanessa Ezenwa** and **Creagh Breuner**. (Breuner, incidentally, is married to Woods.)

"Having several CAREER awardees for two years in a row is simply outstanding," says **Daniel Dwyer**, UM vice president for research and development. "I think this highlights the caliber of faculty we have at this University, and it bodes well that we have so many young rising stars in science."

CAREER grants generally range from $500,000 to $1 million. Briknarova will receive $788,000, Fishman will get $636,000, and Woods will bring in $837,000.

Briknarova, a structural biologist, joined UM in November 2005. She uses a technique called nuclear magnetic resonance spectroscopy to visualize the arrangement of atoms in complex biological molecules to explain how those molecules work. Her lab studies a soluble protein called fibronectin that is assembled by cells into insoluble fibrils. These fibrils are essential for embryonic development and wound healing.

Briknarova says a goal of her lab is to gain insight into the structural changes that occur when soluble fibronectin is converted into insoluble aggregates. "Studying such molecular transformations at the atomic level is challenging, but I love doing research, and I believe that research is an important part of science education," she says. "However, research cannot be done without funding, so I'm very happy about the award and very grateful for it."

Fishman, a plant evolutionary geneticist, came to UM in September 2003. She studies monkeyflowers – plants with small yellow blossoms found across much of the West – to understand the genetic mechanisms and evolutionary processes that lead to variation within and among species. The project funded by the CAREER award will focus on the detrimental trait of pollen sterility. It also will finance development of teaching tools based on monkeyflower research. (For more, see page 6 story.)

"The CAREER award is wonderful because it enables us to study fundamental questions about natural variation, but also supports efforts to bring real research into the classroom," Fishman says.

Woods, a physiological ecologist, came to UM in July 2006. He studies leaf microclimates – the temperature and relative humidity of areas adjacent to leaf surfaces – and how these influence insect-plant associations. He and his lab will study how different leaf microclimates are from the overall climate, how insects interact with these microclimates and how much plants' chemical defenses depend on microclimates.

Woods says his study will illuminate basic questions of insect ecology and will serve as a platform for understanding the effects of global climate change on insect herbivores, including crop pests.

"I'm delighted to receive a CAREER award from NSF," he says. "This grant will allow me to significantly expand my research, support a number of graduate and undergraduate students, and address a set of interesting, fundamental questions." V

Art Woods, Lila Fishman and Klara Briknarova each won an Early Career Development Program grant.

UM scientist honored with pioneering award

Steve Running, UM Regents Professor of Ecology, was among six to receive the first-ever Edward O. Wilson Biodiversity Technology Pioneer Award in April. The awards honor those whose scientific discoveries, inventions or work have helped advance the biodiversity of life on Earth.

Running was chosen for the award for his pioneering and seminal scientific work with climatology, global warming and other aspects of atmospheric science.

UM Regents Professor Steve Running (right) visits with "the father of biodiversity" E.O. Wilson (center) in Bozeman.

"Global ecologists have struggled for many decades to bring biology to the same scales as the atmospheric and ocean sciences," Running says. "Our mapping at UM of daily photosynthesis with NASA satellites achieves some of that goal. I am pleased for (the award) to celebrate that success, and I'm especially honored to receive it personally from **E.O. Wilson**."

Wilson, known as "the father of biodiversity," presented his namesake awards at Montana State University-Bozeman.

Other recipients of the E.O. Wilson award are **David Ward**, MSU; **Jane Lubchenco**, Oregon State University; **Benoit Mandelbrot**, formerly of Yale University and IBM; **Ignacio Rodriguez-Itrube**, Princeton University; and **Michael Soulé**, University of California, Santa Cruz.

Skeleton research featured at Smithsonian

UM anthropology Assistant Professor **Ashley McKeown** has studied skeletons of early 17th-century Jamestown, Va., colonists. They now are featured in an exhibition at the Smithsonian Institution's National Museum of Natural History through Feb. 6, 2011. The exhibition is titled "Written in Bone: Forensic Files of the 17th-Century Chesapeake."

Founded in 1607, Jamestown was the first permanent English colony in the New World. During a three-year postdoctoral fellowship prior to joining the UM faculty, McKeown worked with anthropology curator Douglas Owsley of the Smithsonian and archaeologists at the Association for the Preservation of Virginia Antiquities' Jamestown Rediscovery Archaeological Project to excavate and analyze more than 75 burials from Jamestown.

McKeown assisted with the excavation and analysis of more well-known individuals, such as Capt. Bartholomew Gosnold, one of the founders of the Jamestown expedition and the explorer who named Martha's Vineyard after his daughter.

Grins all around: UM's Ashley McKeown contributed to a display at the Smithsonian.

McKeown also analyzed the skeleton of a young female found buried under a theater in Williamsburg, Va., and, based on tooth modification, was able to determine that she was an enslaved African from the central West African coast.

The interpretation of the lives of 17th-century colonists, both the famous and the mundane, are presented in the wide-ranging exhibition that seeks to inform visitors about life and death in the early Chesapeake, an area that gave rise to many of the nation's most prestigious leaders.

Host it and they will come

Missoula will be a hot science destination in 2010 with UM hosting two prestigious national conferences – the 24th annual National Conference on Undergraduate Research (April 15-17) and the 20th annual conference of the Society of Environmental Journalists (Oct. 13-17).

More than 2,000 undergraduate presenters are expected for NCUR, and when faculty mentors and university administrators are considered, that number swells to 2,500. Conference chair and chemistry Professor **Garon Smith** says about 1,500 attended when UM last hosted the conference in 2000, but the event has grown in popularity, and 2,400 participated in the 2009 NCUR at the University of Wisconsin-La Crosse.

"People really liked our conference in 2000 and basically twisted my arm to bring it back here," Smith says.

NCUR is the nation's premier venue for undergraduate research. It typically boasts presenters from 45 states and 300 institutions. Besides traditional science topics and poster sessions, it includes fine arts, humanities and social sciences offerings such as student dancing, musical performances, plays and films.

"There is hardly a better way to showcase your university than hosting NCUR," Smith says. "If you want to highlight UM as a place where undergraduate research is a hallmark, this is the way to do it."

He says the last conference turned a profit, which was used to fund a program that offers $1,500 grants to UM undergraduate research and humanities projects. The program is administered by the Davidson Honors College.

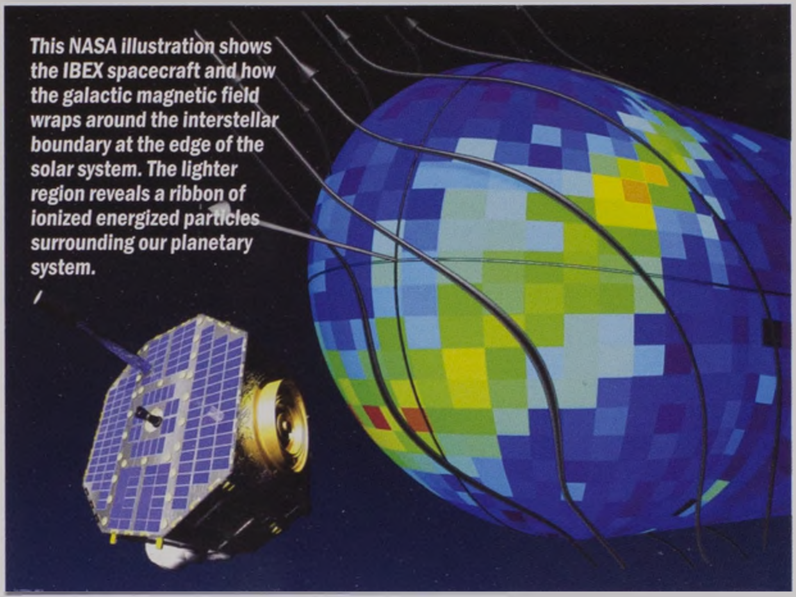
UM never has hosted the SEJ conference, which will bring up to 1,000 reporters, editors, authors, researchers, public relations professionals and others to campus in October. SEJ is the only North American membership association of professional journalists dedicated to more and better coverage of environment-related issues, and several SEJ members have won the Pulitzer Prize.

Universities compete to host the national conference, which in recent years has been held at prestigious research institutions such as Stanford, Virginia Tech and the University of Wisconsin-Madison. This year's Wisconsin event drew 750 participants, and former Vice President Al Gore was a featured speaker, earning the conference national press coverage.

"This will be one of the most exciting conferences UM has ever hosted," says **Rita Munzenrider**, director of University Relations and a primary conference organizer. "This is an excellent opportunity to gain national exposure for our University and the outstanding research being conducted here in Western Montana."

SEJ conferences offer journalism training workshops, presentations by esteemed researchers on pressing environmental issues, networking opportunities and a variety of field trips into the surrounding area. Planning is under way for the 2010 event, but participants likely will visit the Milltown Dam removal site, Flathead Lake, burned forests and other environmental hot spots.

UM scientists help detect giant ring at edge of solar system



This NASA illustration shows the IBEX spacecraft and how the galactic magnetic field wraps around the interstellar boundary at the edge of the solar system. The lighter region reveals a ribbon of ionized energized particles surrounding our planetary system.

Two UM researchers are part of a NASA team that has detected a vast ribbon of energized particles that surrounds most of the solar system.

The discovery resulted from data obtained by NASA's Interstellar Boundary Explorer spacecraft, or IBEX, which was launched last October to map the edge of the solar system. The results were published Oct. 15 in the online version of Science and were one of the prestigious publication's print cover stories in November. (For more information, visit http://ibex.swri.com.)

Dan Reisenfeld and **Paul Janzen** are researchers in UM's Department of Physics and Astronomy. "This ribbon was certainly unexpected, and it's pretty cool," Janzen says.

The interstellar boundary is where solar wind particles from the sun, as well as the magnetic field they carry, encounter and interact with the atoms and magnetized plasma between the stars. In this interaction, some of the solar wind particles scatter back into the solar system where they can be detected by IBEX. The edge region is about 100 times farther out than the distance between the Earth and the sun and about 2.5 times farther out than the orbit of Pluto.

As the sun orbits through the local interstellar medium at 60,000 mph, the interstellar boundary forms a giant teardrop-shaped bow shock around our solar system – sort of like a rock in a stream. The edge region is rounded toward the front of the sun's orbital path and elongated behind.

Reisenfeld says models from before the launch of IBEX predicted more energetic particles would be concentrated at the nose or tail of the interstellar boundary. However, when IBEX completed the first-ever, all-sky map of the boundary during a six-month period, something unforeseen was revealed.

"There was a ribbon of denser ionized particles that surrounds our solar system," Reisenfeld says. "It forms an almost perfect circle around us."

Imagine that the interstellar boundary is a globe turned on its side, and the North Pole points down the sun's orbital path. The particle ribbon is not located at the equator. Instead, it's located more at the Tropic of Cancer. And the ring also is tipped upward slightly on the globe's surface like a jauntily placed cap.

Where does the ribbon come from? The scientists think they have the answer.

"We think it's caused by the interstellar magnetic field, which threads through our Milky Way galaxy," Reisenfeld says.

The sun produces a magnetic field that repels the galactic magnetic field at the interstellar boundary. Reisenfeld says that if one imagines that a magnetic field is like a forest of bungee cords, generally the cords want to hang straight.

"So now imagine that the bungee cords are wrapping around a sphere shape like the interstellar boundary," he says. "Where are they going to squeeze the hardest on the sphere or have the most pressure? It's where they are tangent to the sides of the sphere. So the ribbon we detected correlates to where one would expect the most amount of pressure to be exerted by these magnetic lines that are trying to be straight, but there is an obstruction – our solar system – that keeps them from doing that."

He says the location of the ribbon has allowed them to determine the direction the interstellar magnetic field is coming from – at least locally – to a much higher precision than previously inferred.

The 5-foot-wide IBEX spacecraft has two primary instruments – IBEX-Lo and IBEX-Hi – that detect a range of neutral atoms that are energized at the boundary of the solar system. These instruments were necessary because the interstellar boundary emits no light that can be detected by conventional telescopes.

Reisenfeld designed a section of IBEX-Hi that ionizes, steers and accelerates the particles to where they can be detected. Janzen was a lead scientist for testing and calibrating IBEX, and he helps validate the data coming in from the spacecraft.

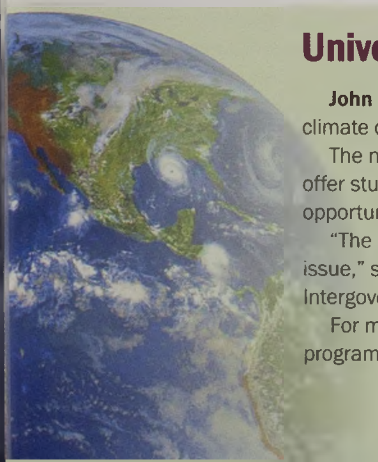
"Our instrument is essentially working perfectly," Reisenfeld says. "That's great, because we are getting really quality data."

IBEX orbits in a highly elliptical eight-day orbit that takes it closer to Earth and then five-sixths of the distance to the moon. The orbit takes the spacecraft beyond the Earth's magnetosphere, which otherwise would drown the signals it receives. At times the moon would block IBEX's view as it created its map of the boundary, which led to an unintended consequence.

"Our team made the first detection of the solar wind scattering off the moon," Reisenfeld says. "We even have a number for the percentage of particles that bounce off the moon. It's about 10 percent."

That discovery made the cover of Geophysical Research Letters.

IBEX is the latest in NASA's series of low-cost, rapidly developed Small Explorers space missions. Southwest Research Institute in San Antonio leads and developed the mission with a team of national and international partners, including UM. NASA's Goddard Space Flight Center in Greenbelt, Md., manages the program for NASA's Science Mission Directorate in Washington, D.C. V



University offers climate change minor

John Warner, former U.S. senator and secretary of the Navy, launched the nation's first interdisciplinary undergraduate minor in climate change at UM during an October lecture titled "National Security and Climate Change."

The new UM Climate Change Studies Program combines rigorous training in sciences with course work in ethics and policy to offer students a unique, multidisciplinary understanding of climate change. The minor prepares students for the challenges and opportunities presented by global climate change and involves them in developing potential solutions.

"The climate change topic is rapidly evolving from only an earth science issue to a technological, economic and sociological issue," says **Steve Running**, UM's Climate Change Studies Program director and a lead author with the Nobel Prize-winning Intergovernmental Panel on Climate Change. "We have designed a broad interdisciplinary curriculum to reflect this expanding focus."

For more information about UM's Climate Change Studies Program, visit http://www.cfc.umt.edu/CCS or call **Nicky Phear**, program coordinator, at 406-243-6932. V

Montana, Kentucky share big water-quality grant

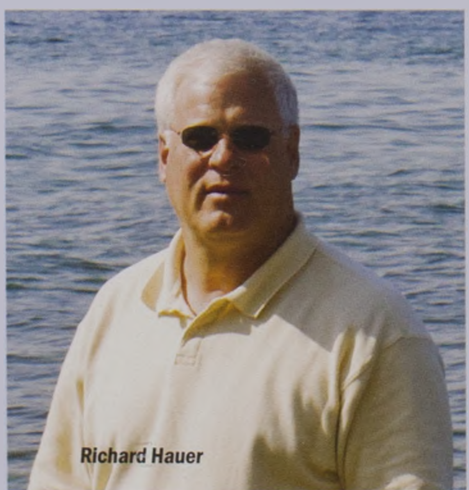
The National Science Foundation has awarded Montana and Kentucky a $6 million grant to install and monitor water-quality sensors in freshwater lakes and streams in both states.

The project – developed and funded through NSF's Experimental Program to Stimulate Competitive Research, or EPSCoR – will manage new and historical data at two of the country's most successful biological field stations, UM's Flathead Lake Biological Station in northwestern Montana and Hancock Biological Station on Kentucky Lake in western Kentucky.

Richard Hauer, UM limnology professor, and **Barbara Kucera**, deputy director of the Center for Computational Sciences at the University of Kentucky, will head up the project, which will include faculty, staff and researchers from six universities. This consortium, called the Virtual Observatory Ecological Information System, will serve as a test project for similar ecological information systems around the nation.

The water-quality sensors at Flathead and Kentucky lakes will provide researchers with key data on climate factors, such as temperature, precipitation and snow dynamics, and on the impact of human land use and environmental changes on freshwater lakes and streams. The consortium will partner with software experts at the Illinois-based National Center for Supercomputing Applications and the UK Center for Visualization and Virtual Environments to analyze the data, and Cisco Systems Inc. will develop environmental data routers for the project.

The new computer network system also will help researchers in both states enhance graduate and undergraduate education and research. The system will develop ecological education courses and offer condensed versions of the data on the Internet. The program will involve underserved and underrepresented students in science and engineering, such as students at Montana's tribal colleges and economically disadvantaged students from eastern Kentucky. V



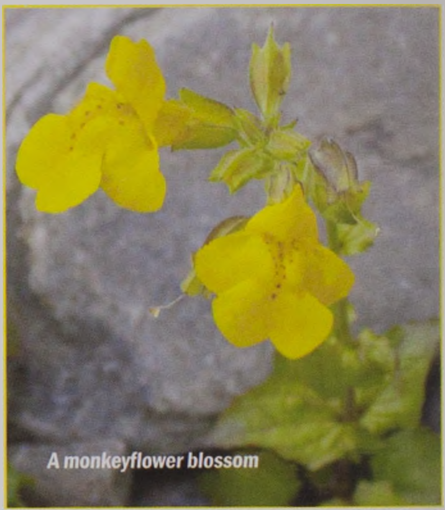
Richard Hauer

UM research reveals chromosomes at war

In a simple world, natural selection would efficiently remove detrimental traits from animal or plant populations. If inherited DNA causes sterility, for example, evolution by natural selection should quickly remove that trait.

The world is a complex place, however, and most populations include stubborn detrimental traits that won't disappear. How does this happen? New UM research may have solved part of the puzzle.

Lila Fishman is a plant evolutionary geneticist in UM's Division of Biological Sciences. While studying monkeyflowers – plants with small yellow blossoms found across much of the West – she uncovered a case in which the detrimental trait of pollen sterility persisted in a population.



A monkeyflower blossom

Under normal circumstances, genes that cause pollen sterility would fail to transmit to the next generation and be eliminated. However, Fishman discovered that while the sterility hurts the plant, it is caused by a chromosome that selfishly helps itself.

Fishman's work on this topic was published in a December 2008 issue of the journal Science. Her co-author is Arpiar Saunders, who did postbaccalaureate work at UM. The work was funded by the National Science Foundation and enabled by a Joint Genome Institute effort to sequence the genome of the yellow monkeyflower.

"We tend to think about natural selection among individuals shaping traits to fit the environment," Fishman says, "but natural selection can also occur at the gene or chromosome level. Genes that can out-compete other genes will spread, sometimes to the detriment of the individual. The basic biology of most plants and animals actually sets the stage for this kind of genetic conflict."

In plants, as in humans, each individual carries two copies of every chromosome (which contains the genes) – one from mom, one from dad. During the first step of sexual reproduction, called meiosis, these paired chromosomes divide to provide a single set of chromosomes for each egg or sperm.

Generally, it is a random coin flip that determines which of the two copies of each chromosome gets transmitted to the offspring. The newly discovered monkeyflower chromosome, however, somehow outraces its partner during meiosis in females and thus manages to get into more than its fair share of the next generation's seeds.

"If a variant chromosome can bias its own transmission during meiosis, it can become common, even if it has negative effects on other traits," Fishman says. "So, the sterile pollen is collateral damage from a hidden war between chromosomes."

Fishman showed that nonrandom chromosomal transmission likely results from competition between structures called centromeres, which are regions of chromosomes that mediate their division during meiosis. While other researchers have shown that genes often behave selfishly, this research offers some of the first evidence to pinpoint selfish centromeres.

"Our work shows for the first time that something associated with centromeres can strongly bias chromosomal segregation and also has fitness costs in natural populations," Fishman says. "This process could be important for bringing deleterious traits into any population, including human populations." V

Bringing home all the honors

Dan Flores, the University's A.B. Hammond Professor of Western History, has earned multiple accolades for his article "Bringing Home All the Pretty Horses: The Horse Trade and the Early American West, 1775-1825," which was published last year in Montana: the Magazine of Western History.

His article won the magazine's Vivian A. Paladin Best Article for 2008 award and the Western Heritage Association and National Cowboy Museum's Outstanding Magazine Article 2009 Wrangler Award. "Bringing Home All the Pretty Horses" also earned the 2009 Friends Choice Award from the Friends of the Montana Historical Society, the Western History Association's Ray Allen Billington Prize for Best Article on the West 2009, and a Finalist Award for 2009 Best Western Short Nonfiction from the Western Writers of America.

In the article, Flores argues that trade in wild and Indian horses was one of the earliest economies in the West, funneling western horses to the American frontier east of the Mississippi River. V

Two ponderosa pines crushed the bio station's travel trailer, which was used for research around the state.

Freak storm topples biological station trees

A winter storm that rolled across northwestern Montana last December hammered the 80 acres of old growth forest at the University's Flathead Lake Biological Station, located 18 miles north of Polson on the east shore of the lake.

Many of the ancient ponderosa pines that gave the station grounds its character were blown down.

"We lost 30 or more of our biggest p-pines, and about a third of the larger grand and Douglas firs on the entire grounds went down," station Director **Jack Stanford** says. "We had thousands of board feet of solid old timber on the ground. It is very sad."

Stanford has taught ecology among those trees for nearly 40 years.

"I thought their greatest danger was bugs, not wind," he says. "Some of these trees were over 400 years old. Certainly there is no record of a windstorm causing this kind of damage in the 110-year history of the station."

Stanford says most of the trees were uprooted rather than snapped off – perhaps because the ground was very dry and not frozen.

"Fortunately none of our buildings were seriously damaged by falling trees," Stanford says. "Roofing of the Freshwater Research Lab was blown off and two cabins got direct hits from trees, but otherwise we are in pretty good shape. But the biological station has a vastly different look with all the big trees down."

Nitrogen buildup impacts mountain ecosystems

A recent study involving researcher **Cory Cleveland** contends that many mountain ecosystems, hammered by years of pollution, may be approaching toxic conditions.

Cleveland, an assistant professor in UM's College of Forestry and Conservation, was part of a team that studied nitrogen pollution in the Tatra Mountains of Slovakia. Atmospheric deposition of nitrogen was heavy there during the 20th century because of the industrialization of Eastern Europe.

As deposition of atmospheric pollutants, especially nitrogen, are projected to increase dramatically during the coming decades, the researchers wanted to understand how a high-country ecosystem already impacted by decades of pollution would respond to new inputs. So they purposely added varying levels of nitrogen fertilizer to several study plots above the tree line in Tatra National Park.

"We added nitrogen at rates that are essentially equivalent to what you might expect going into the future," Cleveland says, "and we saw big changes in the ecosystem. Plant growth decreased, and soil chemistry was altered."

Results of the study were published in Nature Geoscience.

Nitrogen makes up 78 percent of the atmosphere, where it's a harmless gas. However, human activities such as burning fossil fuels or manufacturing fertilizers can turn nitrogen into forms with a host of negative environmental consequences.

If leeched into streams, lakes and ultimately the ocean, nitrogen can cause algal blooms, oxygen deprivation and aquatic dead zones. Human infants drinking nitrate-laced groundwater can get blue baby syndrome, a blood disorder that prevents hemoglobin from carrying oxygen to the body's cells and tissues.

Nitrogen compounds emitted from many human activities can rise into the atmosphere and fall downwind as precipitation. Because mountains get more rain and snow, and alpine ecosystems above the tree line don't produce the biomass to take up the nitrogen, it builds up in soil.

"It's kind of scary when you consider how much we depend on mountain ecosystems," Cleveland says. "A lot of places obtain all of their drinking water from the melting of mountain snow."

The study started in the summer of 2002. After arriving in Slovakia, it took three hours for the UM researcher and his partners to backpack to their study area, carrying both fertilizer and the water needed to mix it.

"We added three levels of nitrogen, and under every treatment we saw declines in plant biomass," Cleveland says. "There were few significant changes in the composition of species, but the species that were there grew a lot less."

He believes that with increasing nitrogen deposition, the acidity of the soil is increased. This causes some of the essential nutrients plants need to become mobile and leech out of the system.

"We saw declines in things like calcium and magnesium," Cleveland says, "and we saw increases in iron. Iron only becomes detrimental to plants growing in extremely acidic soil because acid can convert iron into a form that plants can take up. So we saw iron increases in the plants as well, and at high concentrations this can become toxic to plants."

So are alpine areas in Western Montana currently threatened by nitrogen deposition? No, Cleveland says, because the mostly sedimentary rocks of Big Sky mountains are buffered pretty well against inputs of acidity. Montana also is fortunate to lack major industrial centers due west that send high levels of nitrogen up into the high country. However, many other mountain ranges around the globe may be on the brink of big changes.

Cleveland's study partners were **William Bowman** of the University of Colorado, **Luboš Halada** and **Juraj Hreško** of the Slovak Academy of Sciences, and **Jill Baron** of the U.S. Geological Survey.

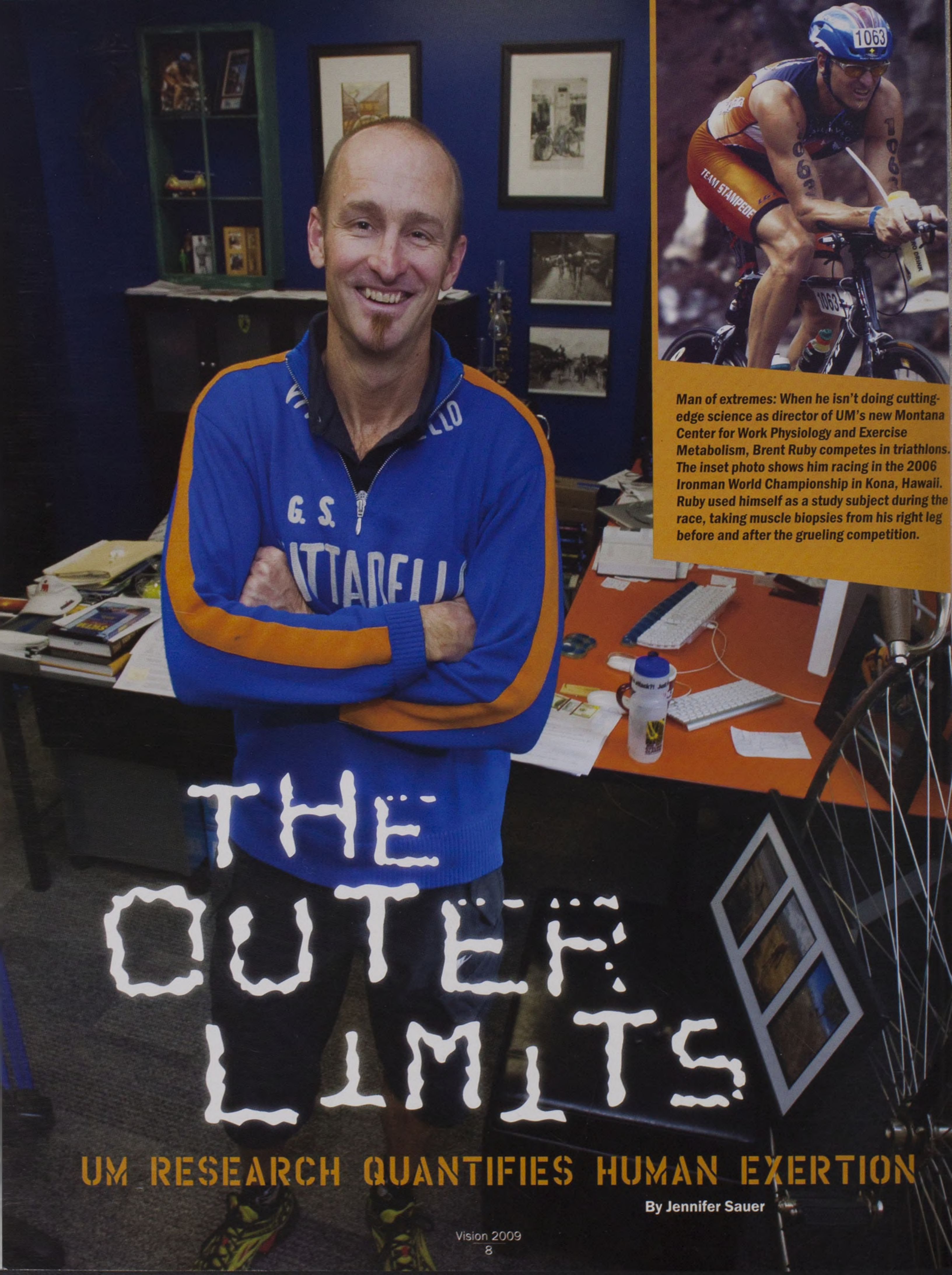
Research finds beetles with three male types

Doug Emlen, a UM evolutionary biologist, has helped discover that several beetle species produce three varieties of males. The typical male dung beetle, for example, grows large horns to use as weapons to battle sexual rivals. A second smaller variety of male doesn't grow large horns – perhaps because of environmental deprivation – and has to employ sneaky tactics to mate with females. And now a third type of male has been discovered – those that resemble females. Researchers suspect this female-mimicking adaptation allows the beetles to use deception to evade combat and earn sexual encounters.

Emlen and **Mark Rowland** of the University of New Mexico used National Science Foundation funds to study the development and evolution of male dimorphism in insects. They were surprised to find that many species of beetles are capable of producing not only two but three different types of males. These three male forms differ widely in the weapons they employ in competing with other males for mating opportunities.

The study first discovered male trimorphism in dung beetles, but once recognized, the researchers found it in other families of beetles as well, involving different weapon systems – head horns in dung beetles, mandibles in stag beetles and ventral spines in weevils. A common feature in these trimorphic species is that one of the three male forms is always female-like in morphology.

Their work was published in the Feb. 6 issue of Science.



Man of extremes: When he isn't doing cutting-edge science as director of UM's new Montana Center for Work Physiology and Exercise Metabolism, Brent Ruby competes in triathlons. The inset photo shows him racing in the 2006 Ironman World Championship in Kona, Hawaii. Ruby used himself as a study subject during the race, taking muscle biopsies from his right leg before and after the grueling competition.

THE OUTER LIMITS

UM RESEARCH QUANTIFIES HUMAN EXERTION

By Jennifer Sauer

THINGS WERE NOT GOING WELL FOR RUNNER 162.

Just 42 miles into the Badwater Ultramarathon – a 135-mile, two-day race in California dubbed "the world's toughest footrace" – the runner staggered into the aid station at Stovepipe Wells and collapsed into a waiting chair.

Temperatures of more than 110 degrees and the challenge of covering a distance on foot that many people don't drive in a day were beginning to take their toll.

Fortunately Runner 162 was not just a Badwater participant. He also was a research subject in a hydration study conducted by University of Montana Research Professor Brent Ruby.

So in addition to taking in food and fluids at the aid station, Runner 162 gave blood and urine samples to a handful of UM researchers working out of a modified Airstream trailer. Ruby and his fellow scientists tested the samples immediately for serum electrolytes and stored a portion of the urine sample to evaluate the hydrogen trace (^2H_2O) their subject had ingested hours before starting the race.

Within two minutes, they provided Runner 162 with a printout detailing why he was suffering: High water turnover because of excessive sweating had depleted his sodium levels to a point where his ability to continue was in jeopardy. Armed with this knowledge, Runner 162 could reverse his downward spiral.

"We said, 'Here is your data,'" Ruby explains as he recounts the story from his office in McGill Hall. "'It's not that hard. Just up your sodium intake and you should come right back to normal.'"

Runner 162 heeded the scientific advice he received from the researchers.

"He finished and had a time that was quite a bit faster than his previous time," Ruby says. "Having that data at that point really helped him to make the necessary adjustments to bounce back."

The data also gave Ruby the opportunity to use groundbreaking science to gauge the limits of human energy expenditure.

As director of UM's new Montana Center for Work Physiology and Exercise Metabolism, Ruby and center research staff Dustin Slivka, John Cuddy and Walter Hailes strive to create a better understanding of applied human physiology, working in both laboratory and field settings.

Center researchers study how much the human body can endure, using their results to ensure safety and high performance in tough work environments such as special military operations, wildland firefighting and ultra-endurance races.

The WPEM facility, which was completed as an addition to McGill Hall in fall 2008, includes a 3,550-square-foot biochemistry lab and a 10-by-10-foot climate-controlled environmental chamber that researchers can use to manipulate temperature and humidity. WPEM researchers also can take their lab on the road with a solar-powered Airstream trailer.

Ruby, who also is a research professor in UM's Department of Health and Human Performance in the College of Education and Human Sciences, uses the new state-of-the-art facility to push the limits of energy expenditure research much like the endurance athletes he studies push their bodies in competition.

To gauge energy expenditure, Ruby uses a technique modified by Dale Schoeller of the University of Wisconsin. The method involves using water labeled with two stable isotope tracers, one oxygen (^{18}O) and one hydrogen (^{2}H). These tracers "label" the water in the body, and researchers can then monitor those tracers as they exit the body through respiration, sweat, urine and possibly – on a bad day – tears.

"However water leaves the body," Ruby explains, "the hydrogen tracer leaves the body through those exit routes. The oxygen tracer leaves the body through all of those exit routes, but it also leaves the body attached to expired CO_2 as the result of metabolic activity. If you look at the exit rates, you can calculate CO_2 production.

"If you have that in hand, then you can calculate the total energy expenditure in a number that most people understand, which is kilocalories per day," he says.

Ruby has worked closely with Schoeller since the mid-1990s to hone the tracer technique for short-term measurement periods and take the research method to a new level. Recently, Ruby and his team have captured human energy expenditure measurements for 12 to 24 hours during endurance competitions.

THE ENERGY DEMANDS OF THE (FIREFIGHTING) JOB ARE PRETTY MUCH WHAT THE MILITARY HAS SHOWN FOR MARINES, NAVY SEALS, ARMY RANGERS, DURING ALL SORTS OF JUNGLE OR ARCTIC ACTIVITIES....

It all began in the late 1990s, when Ruby first used the technique to study wildland firefighters over a three-day period. By taking urine samples before, during and after shifts on the fire line, the researchers could monitor both energy expenditure and water turnover. The study found that the firefighters' daily energy expenditure was between 4,000 and 6,000 calories, while water turnover was about seven liters per day.

That study was funded by the U.S. military to gauge the caloric needs of soldiers in combat.

"The energy demands of the (firefighting) job are pretty much what the military has shown for Marines, Navy SEALS, Army Rangers, during all sorts of jungle or arctic activities," Ruby says. "So we were pretty happy with that study because that was the first time we had ever used that technique."

Like the adrenaline junkies he would come to study, Ruby was hooked.

His future studies focused on Iditarod mushers, Air Force Special Ops teams, mountaineering expeditions and arctic explorations.

"Everything seemed to come back to the 4,000 to 6,000 calories in a 24-hour period," Ruby says. "We kept thinking there has got to be some other situations out there that certainly have higher rates of energy expenditure for a single day."

In 2005 Ruby, a triathlete himself, set his sights on studying racers at the Ironman World Championship in Kona, Hawaii. Ironman participants compete in a 2.4-mile swim, a 112-mile bike ride and a 26.2-mile run – raced in that order and without a break.

"We thought the environment is perfect for this because the rate of water turnover is going to be exceptionally high, meaning they are going to lose a lot of sweat," he says. "And they are going to have to replace that, otherwise they are not going to be able to finish."

But without a grant to fund the study, Ruby could only commit limited resources. Using just a handful of subjects in 2005 and at the championships the following two years, the UM team of researchers found that the racers were averaging an energy cost of between 8,000 and 9,500 calories over the course of the 10- to

(Above) WPEM scientists have studied athletes in the Ironman championships in Hawaii three times. (Below, left to right) Walter Hailes, Dustin Slivka, Ruby and John Cuddy brave the heat to examine athletes at an ultramarathon in Death Valley, Calif. (Right) Ruby does a mid-race blood draw on a volunteer in the Western States 100 ultramarathon in Squaw Valley, Calif.

12-hour event. At the time, their findings were some of the highest measurements obtained using this technique in humans.

"There are other ways to capture it, but this double-labeled water technique is the gold standard for free-living human measurements in the field," Ruby says.

Still not satisfied with the 9,500-calorie limit, Ruby looked to the most prestigious endurance running event in the United States: the Western States 100 Mile Endurance Run in Northern California. Using funding from the U.S. Air Force, Ruby, Slivka, Cuddy and Hailes traveled to California with their mobile Airstream lab and found 12 runners willing to participate in their energy expenditure study. Ten finished the grueling race.

"The average finish time of our subjects was around 24 hours," Ruby says. "The average energy expenditure for the whole race was approximately 16,000 calories, which is enormous for a single day. The range was from about 11,000 (calories) all the way up to 19,000, and very much related to body size.

"Nobody has even come close to these calculations with humans before," Ruby says. "We think this is probably close to the human ceiling for a single day."

The following year at the Badwater Ultramarathon demonstrated that race participants had water turnover of about 36 liters during the two-day event. The racers started with an average total body water of approximately 40 liters and "turned over" nearly 90 percent of their total body water – an extreme example of hydration needs.

"That's almost a total replacement of your body water, which is incredible," he says. "That was probably one of the most impressive measurements that we've got in all of the studies."

Obtaining data from subjects who are midway through a race or between shifts on the fire line presents its own set of challenges for Ruby and his researchers. To meet its unique needs, WPEM purchased and customized a 25-foot Airstream in 2006.

The bathroom now serves as small-scale sample-processing lab, while the beds in the front double as sleeping quarters and space to take muscle biopsies. Solar panels provide some of the juice necessary to power the lab's computers and machines.

"That facility makes the fieldwork so much easier because everything is there – all the supplies for sample collection," Ruby says. "We can store the samples; we can process the samples. We can do all the computer work that's necessary and it's great. And we can live in it, which is just awesome. That Airstream just makes life great."

It also might help to bring more grant dollars to UM. Ruby currently has a grant proposal on the table with another military branch that sought WPEM's involvement because it already has the capacity to conduct research in the field.

"People really like the idea of a facility being able to be that mobile," he says. "When we did a fire study last summer, we were out in the middle of a pasture. And we had to have lights. We had to have computers. We had to have all that power because almost everything is collected in

(Top, left to right) Tyler Tucker, Cuddy and Slivka take a break outside the mobile Airstream trailer lab during a study on firefighters working near Elmo in 2008. (Below) This research caravan was used to study cyclists during the 2,000-mile Giro D'iscovery project.

WPEM
montana center for work physiology and exercise metabolism

the dark. It seems like we can never get away from the early morning hours. We can never get out of the dark. So being able to use that trailer for sample collection is just priceless."

The mobile lab's maiden voyage took place during the summer of 2007 when Ruby hit the road with a

Slivka (top) prepares muscle samples taken from riders in the Giro D'iscovery project (upper right), which took riders from Montana to Colorado. (Right) Slivka and Ruby take a post-ride muscle sample.

dozen cyclists and followed them as they rode 2,000 miles from Missoula to Colorado and back. Along the way, the researchers used cycle computer systems to estimate daily energy expenditure from real-time power input.

"If we just used the Airstream for that cycling study alone and we burned it to the ground, it still would have been worth its weight in gold," he says. "We would have never been able to do that study without it. And since then we've taken it to Badwater, Western States, fires, all over the place. We've had it all over the Western U.S. It's awesome."

The Airstream also helps Ruby convince research subjects that they can participate in his studies with minimal disruption.

"Most of the time when we swoop in, we have a really hard time getting subjects unless we've really planned it out ahead of time," Ruby says. "Sometimes people are apprehensive to work with us, or they're worried that their race is going to be disrupted or their job is going to be disrupted.

"I would say, at the end of the study, they have embraced the concept of being a participant," he says. "They really have a great time with our small lab group and the data that we give them, they just totally dig it. It's like we are this rolling goodwill tour of science just collecting data along the way."

But what does all this data and research mean to the world?

"That's always the million dollar question. The human body is mighty," Ruby says of his latest energy expenditure findings. "I think this data provides an appreciation for the capabilities that the human body has. It's tremendous and adaptable. It demonstrates how humans in general under use the physiological gifts that the body has to offer."

Ruby maintains that ancient humans likely had similar energy expenditures during the hunts that their survival depended on.

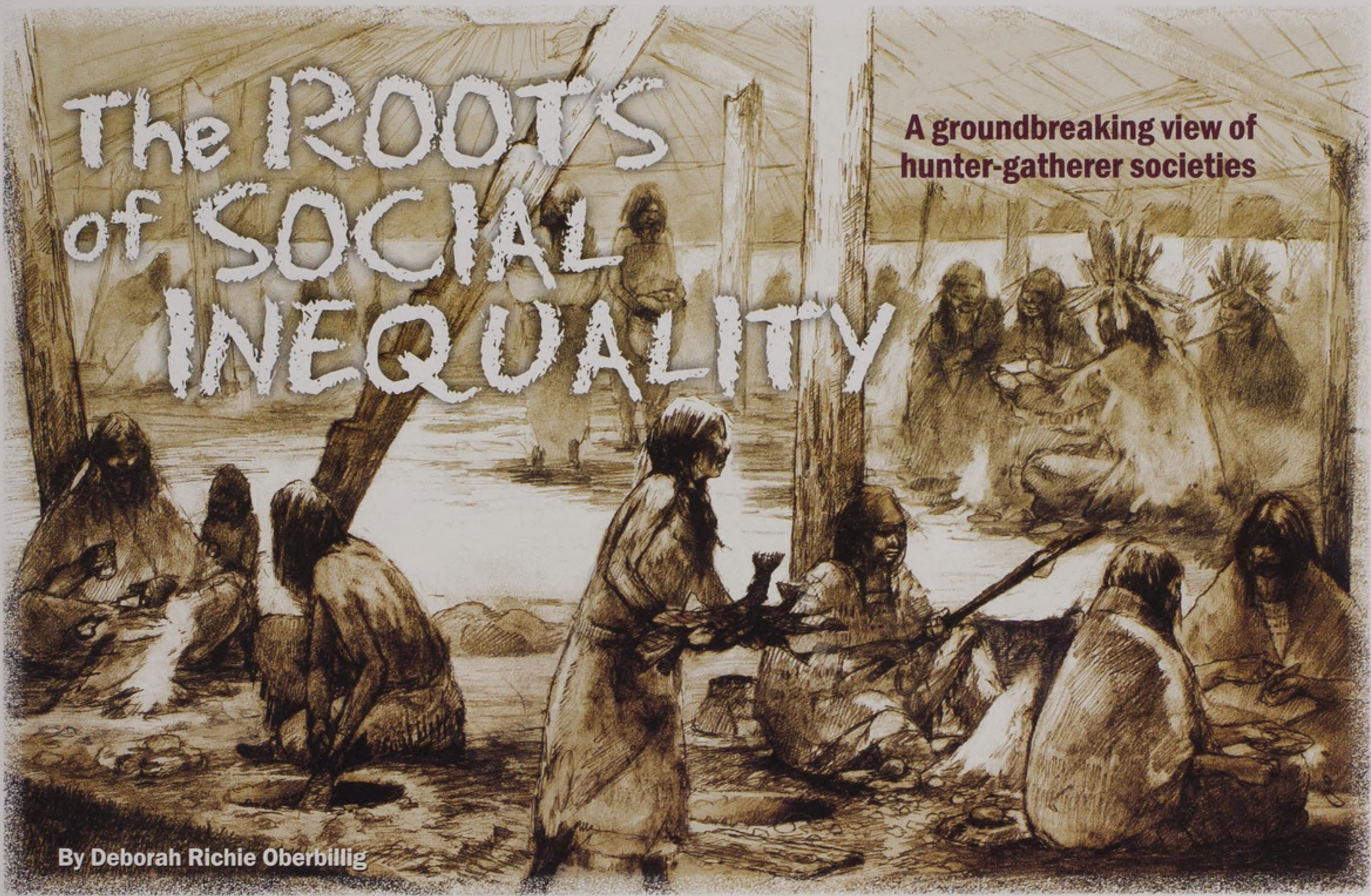
"Thousands of years ago the human ceiling was probably identical to what it is now," he says. "But now we don't have the need to achieve it. So we create environments that are competitions to achieve it. Back then, it was survival. Now it's just an expensive hobby."

Ruby doesn't think the human ceiling has changed by any means.

"There's no reason why it should," he says. "It's changed for a lot of people just because they have no interest in jumping that high. They are content with living around what the food labels recommend at 2,000 calories a day.

"But I always say how boring life would be if you only expended 2,000 calories a day. You miss out on the poetry that the body has to offer when your energy expenditure is so dramatically low. It's designed to withstand a tremendous amount of activity. It just shows what the human body can celebrate."

For more information, e-mail brent.ruby@umontana.edu.



The Roots of Social Inequality

A groundbreaking view of hunter-gatherer societies

By Deborah Richie Oberbillig

The sun blazing down between the lofty peaks of British Columbia's middle Fraser Canyon falls on the archeology crew excavating housepits in the grasslands above the Bridge River. The pace is slow and meticulous. Charcoal ash floats in the dusty air.

"It's a dirty job, but someone has to do it," says Anna Marie Prentiss, the UM archeology professor who led the National Science Foundation-funded dig from 2003 until its completion this past summer. Bridge River joins several exceptionally large and well-preserved ancient villages near the town of Lillooet. People inhabited the Bridge River village from 1,800 to 1,000 years ago, and then returned during the past 400 years. Their descendents live nearby.

Sifting through the layers, Prentiss and her team have unearthed compelling evidence that social inequalities likely originated in response to a decline in fisheries that ultimately would force the villagers to leave. She's part of a revolution in attitudes toward the Archaic period of hunting and gathering, once thought to be the least interesting time in North America's past.

"Even the plateau where I work is considered in between the exciting spots – with the Northwest coast on one side and the Plains bison hunters on the other," Prentiss says. "It's analogous to the whole view of the Archaic."

Ask the local children who've toured the site and the word "boring" never comes up, but a certain name always does with an eagerly raised hand – Indiana Jones. While she laughs at the reference, in truth, Prentiss could easily slip into an archeologist role in the next movie installment. She's tall and lanky, with long brown hair and blue eyes. In the field she wears a cowboy hat to shield the sun. Under the brim, her face often is smudged with charcoal.

Prentiss sets a grueling schedule on days when the heat can be blistering. The crew of primarily graduate students begins at 6:30 a.m. and ends at 3 p.m., with a half-hour lunch break. The only complaint tends to be, "Why stop for lunch?" That's the kind of obsession typical of the Bridge River dig. Compared with sites where archeologists sort endless piles of fire-cracked rocks, here the team discovered jade tools, soapstone ornaments and pipes, shell beads from the Pacific coast, obsidian, copper beads and copper fishhooks.

Using trowels and bamboo sticks, the crew excavated trenches that were strategically

(Left) UM anthropology Professor Anna Prentiss. (By Duggan Backhouse-Prentiss) (Above) An artist's rendition of pithouse life at Keatley Creek village around 1100 A.D. Note the stepped log that was used to enter the pithouse. (By UM anthropology graduate student Eric Carlson)

Digging deep: UM doctoral student Lisa Smith looks up from her excavation at the Bridge River village in British Columbia. The former housepit was first occupied 1,600 years ago, and layers of roofs and floors can be seen in the walls. Many students will spend six weeks carefully digging one such hole. (Inset) A nephrite jade adze found in Housepit 25. The woodworking tool is 300 years old.

chosen to intercept kitchens and storage areas. They mapped projectile points and other obvious finds on each floor; calculated ratios of sand, silt, clay and charcoal; and scraped up sediments to shake through a mesh screen to pick out fragments.

"It's not a spectator sport," Prentiss laughs, "but this year we found neat stuff."

In large storage pits, for example, they uncovered rolls of birch bark with fish bones inside, giving insight into domestic life. Just as we might clean a fish, wrap the bones in newspaper and toss it out, so the women used birch bark for the same purpose.

Every discovery helps build a view of life 1,100 years ago when Bridge River reached its zenith with as many as 1,000 people living in the village. Like most prehistoric sites, archeologists strive to recreate life from the ruins. However, here in the mid-Fraser villages they gain extra insight from a priceless source, a book titled "The Lillooet Indians." It was written by ethnographer James Teit in 1906, just before many of the cultural traditions were lost in the wake of Euro-American settlement.

In the yellowed pages are the recorded oral history of the elders, whose knowledge extended back 400 years to the more recent period when the villages were smaller than during the first occupation. Teit wrote of fortified villages containing an elaborate hierarchy. Each household had a chief. A set of households formed a clan that was overseen by an even higher chief. Above that person might be a super chief presiding over multiple villages as clans split and moved. The path to a chief could be either hereditary or nonhereditary.

When did such a social hierarchy evolve and why? Prentiss believes the answer lies in the heyday of the mid-Fraser villages and shortly before the period of abandonment. Today's Bridge River village descendents, the Xwisten people, are thrilled to at last see the housepit excavations after years of attention devoted to a nearby village at Keatley Creek. They are anxious to retrieve missing links in their history.

Prentiss' Bridge River findings suggest that differences in social rank arose from savvy families struggling to keep households together as the salmon runs dwindled and their food source collapsed. To survive, one family might invite another to join them under their roof, but there was a price. That new family would not inherit the same rights. The inequality came about because the heads of houses were trying to preserve their families and compete with others in a time of resource stress.

"Just before 1,000 years ago, you find that some houses were higher ranked than others," Prentiss says. "They were bigger, with more storage pits in the floor."

Her work at Bridge River helped explore the doubts that had plagued her since the 1980s when she researched her dissertation at Keatley Village under the guidance of archeologist Brian Hayden, who continues his excavations today and proposes an alternative view of how social inequalities developed.

Hayden asserts that social inequality existed at Keatley Village when the salmon fishery was plentiful for all. He believes that certain individuals stepped up to hoard more supplies and offer superior potlatches – the Northwest coastal tradition of hosting feasts and giving gifts to gain prestige.

"It made no sense to me," Prentiss says. "Why would people allow themselves to go into debt to others if everyone had the same access to resources?"

Supported by three National Science Foundation grants totaling $348,000, Prentiss focused on Bridge River for a fresh perspective on the mid-Fraser Valley Archaic. The clincher for her resulted from the arduous task of carbon dating to affix time periods in the Bridge River village. That dating showed the village expanding by 400 percent from 1,800 to 1,100 years ago. As it grew, the pattern shifted from a random scattering to a clearly planned design featuring two arcs containing big and small houses.

The time of changing house sizes and arrangements tied closely to the fishery that sustained them. A worldwide phenomenon known as medieval warming caused the salmon fishery to crash as the ocean warmed. As the fish dwindled, the social hierarchy blossomed, but ultimately even those efforts to consolidate resources failed.

Here, in the remote mountainous interior of British Columbia, archeologists are finding relevance to worldwide events that shaped human history. Prentiss is fascinated by those connections and to the larger questions of cultural evolution that she explores as lead editor on a new book to be released in fall 2009, "Macroevolution in Human Prehistory: Evolutionary Theory and Processual Archaeology."

While her fieldwork at Bridge River has ended, her curiosity remains insatiable. She would like to return to delve into one certain housepit that's not actually one house but 14 – all built on top of one another in about 15-year cycles. Traditionally, when a house wore out, the family burned it down and built a new one on top of it. Here, each floor is sealed and preserved. Within the clay lies the story of change from a pre-ranked to a high-ranked village. Prentiss lights up as she describes this gem of finds. Archeology is an obsession for her that dates back as far as she can remember.

"You can still see my scribblings of cave drawings and dinosaurs at age 3 on the underside of my parents' coffee table," she admits.

She took her first college anthropology class in Florida and never looked back, soon joining an underwater excavation of a Paleo-Indian mastodon site, followed by a dig at a 3,000- to 7,000-year-old Archaic village, also in Florida. Her field and academic studies have led her to Louisiana, Wyoming, British Columbia and Montana.

In every field site, a new story always emerges. During a 2006-07 excavation for the Chippewa-Cree tribe in Montana, Prentiss and students sifted through 3,000-year-old fire-cracked rocks of prehistoric sites slated to be flooded by a new reservoir. They found little else for clues, but analysis in the lab revealed the faint traces of blood and plants, the remains of sheep, bison and yucca roots. A vanished people of the Bears Paw Mountains came to life from the rocks.

Archeology digs may fall short of Indiana Jones-style drama, but the painstaking work can lead to revolutions in thinking. The Archaic period turns out to be a far cry from a simple life of hunting, fishing and gathering nuts and berries. While the ancient people of Bridge River may not have created elaborate pottery or farmed the land, their intricate social systems give us food for thought about our own system of rank, prestige and wealth. V

(Right) An artistic vision of villagers processing deer at Keatley Creek around 1100 A.D. (By Eric Carlson). (Below) Students work on Housepit 20 at the Bridge River excavation site. (Inset) Cracked hearth rocks discovered in the remains of Housepit 25.

TAINTED TREES

By Cary Shimek

It can be eerie at a Superfund site.

That point was driven home for UM scientist Tony Ward in 2006 while working on forested land surrounding the closed W.R. Grace vermiculite mine five miles east of Libby. It was one of the hottest days of summer, and Ward – along with research partners Julie Hart and Terry Spear from UM's Montana Tech – was dressed head to toe in a white hazardous material suit with little ventilation.

A guard hired by the Environmental Protection Agency unlocked the gate blocking Rainy Creek Road to admit the scientists to the property, and they drove up the blacktop toward the summit of Vermiculite Mountain, where the mine is located. After a few miles the trio parked and – looking a bit like escapees from the Apollo Program – began to cut and stack firewood in the hot sun.

"There is nobody there, and it's just very strange," Ward says. "You look out, and it looks like a regular Montana forest. But it's actually loaded with asbestos fibers everywhere. It's very odd being up there, because you can't see the asbestos.

"It all looks so normal."

The mine was founded in the 1920s after it was discovered that vermiculite "popped" when heated, creating a material with air pockets suitable for insulating buildings and conditioning soil. The mine boosted the economy of Libby for 70 years and at one time produced more than 80 percent of the world's vermiculite.

Research reveals another public health threat from asbestos

UM researcher Tony Ward demonstrates how to take a bark sample to search for asbestos.

However, this mineral wealth was laced with a particularly nasty form of asbestos that breaks down into needlelike fragments that can become airborne and inhaled by people, leading to diseases such as lung cancer, asbestosis and mesothelioma. The mine became a volcano of pollution amid the scenic landscape, sickening hundreds of miners, their family members and others. More than 200 deaths in the area have been attributed to mine activities, and in June 2009 the EPA announced that the Libby asbestos site constituted the nation's first Public Health Emergency.

Besides the human toll, the mine dusted the surrounding forest during its decades of operation, and the UM researchers wanted to know if the trees were safe to harvest – especially in an area where many people depend on wood as their sole source of heat in the winter.

Researchers Terry Spear (left) and Tony Ward harvest firewood at the Superfund site and later found substantial asbestos fibers on their hazmat suits.

Ward says working in those hazmat suits that day made the forest seem like the surface of the sun.

"It was the most god-awful thing you can imagine, being in those sweat suits," he says. "We all developed severe headaches, and I think we only lasted an hour before we almost had heatstroke. We had the chain saws out and we were working, and nobody wanted to be the first to say 'I've got to get out of here.' But eventually we looked at one another and admitted it wasn't working."

So they retreated down the mountain, only to return that fall – after a few snows – to learn what secrets the trees would tell.

The researchers originally wanted to prove the trees around the mine were clean. In collaboration with Ward, Hart and Spear first collected tree-bark samples there in November 2004 as part of a commercial logging study.

"Those trees are like stands of money out there, so we wanted to figure a way to harvest them in the contaminated areas as a source of income for the Libby community," says Ward, a research assistant professor in UM's Center for Environmental Health Sciences. "We were thinking that tree harvesting should be fine. Our thought was that most of the contamination at the Superfund site would be in the ground. Our hypothesis was that when you cut and drag a tree through contaminated soil, that's when the tree could get dirty."

They collected 10-centimeter-square chunks of bark from standing trees at three sites: at the edge of the mine, at a midpoint along Rainy Creek Road and near the gated entrance to the property. Ward then badgered Jim Webber, one of the world's leading asbestos experts with the Wadsworth Center of the New York State Department of Health, to analyze the bark samples. ("I cornered him at a conference, and he eventually agreed to do it," Ward says.)

Webber developed a bark test in which the sample was "ashed" so that all the wood was burned away, leaving only the asbestos fibers, which, of course, are highly heat resistant. These fibers were then placed on a filter-like grid to help with counting and viewed under a transmission electron microscope.

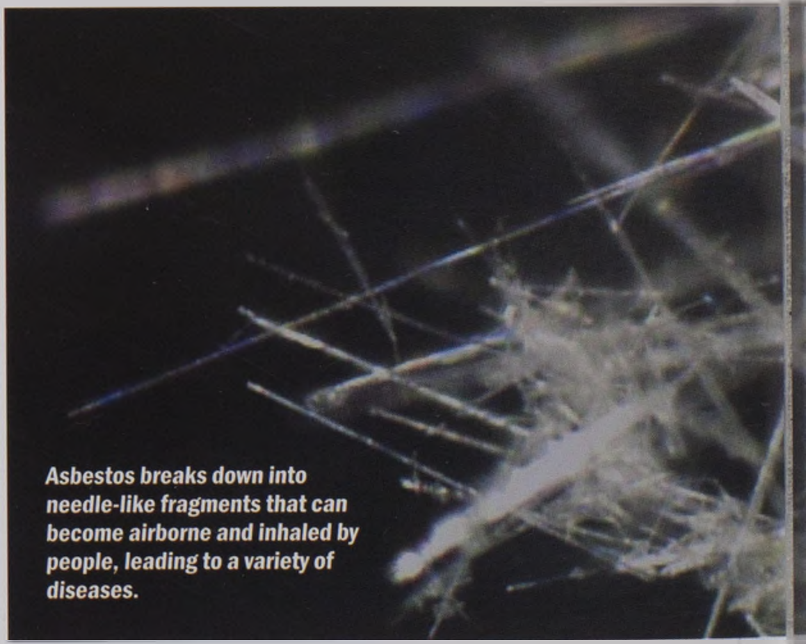
There never had been a tree-bark standard for asbestos before. However, one industrial hygiene textbook says anything over 100,000 fibers per square centimeter of a clean, smooth surface area should be considered contaminated.

Bark is definitely not smooth and clean, and its wrinkled surface presents a much larger surface area, so it can't be directly compared to a flat surface. But a lodgepole pine adjacent to the mine offered 260 million fibers per cm^2 of bark. A similar tree along Rainy Creek Road had 110 million fibers per cm^2, and one near the gated entrance miles from the mine still had 54 million fibers per cm^2.

"We were pretty astounded by the results," Ward says. "It turns out these trees are like asbestos dust mops."

Ward returned to Libby in June 2005 to sample the bark of trees right in town. The results: Asa Wood Elementary School had no fibers detected, but both the Firemen's Public Park and Libby Middle School had 250,000 fibers per cm^2, and the railroad – gateway for shipping the tainted vermiculite around the nation and world – had 5.8 million fibers per cm^2.

How far from the mine does the tree bark contamination extend? Ward suggested a program in which bark was sampled at regular intervals in eight directions leading from the mine, and the EPA conducted the program in May 2008. It found asbestos-laden trees more than eight miles from the mine.

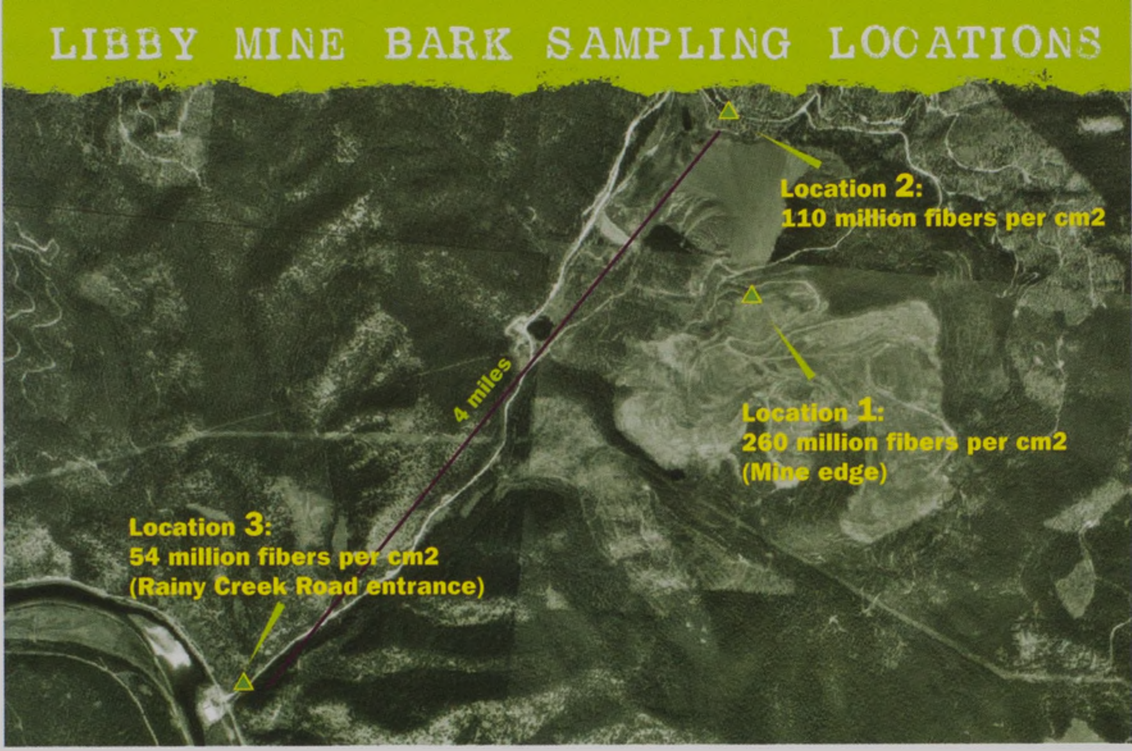


Asbestos breaks down into needle-like fragments that can become airborne and inhaled by people, leading to a variety of diseases.

The only direction where "non-detects" became evident before sampling ended was north, after about five miles. To the east, contaminated trees were found miles away on the far side of sizable Lake Koocanusa. To the west, sampling stopped at the edge of Libby, where contaminated samples were found.

After sampling confirmed the trees were contaminated, the researchers decided to focus on the implications that might directly affect members of the community. For instance, what happens when you harvest the wood? (This was an important question, as Libby residents are heavily dependent on woodstoves for residential home heating throughout the cold winter months.) They did a study on that in 2006 – the same research in which summer heat forced them from the mountain. The scientists used chain saws and cut and stacked wood. Afterward, they took wipe samples from their hazmat suits. In the summer, some wipes produced a contamination level of more than 100,000 fibers per cm^2. When they returned later that year in October, their highest wipe samples were about 36,000 fibers per cm^2.

"Having that heat chase us from the mountain actually turned out to be a good thing, because it inadvertently gave us a seasonal comparison," Ward says. "We learned that you get a lot more asbestos on your suits – or your clothes – when it's hot and very dry versus when it's cooler and wetter."



They determined that it can be harmful to harvest the wood, so then what happens when you burn it? In 2007 the trio burned contaminated wood as part of a combustion study. It was another surreal scene at the Superfund site as they set up brand-new woodstoves on paved Rainy Creek Road in their hazmat suits.

"We burned it just like someone would in their home," Ward says. Ash samples were collected, and wipe samples were taken within the ductwork. "We learned that asbestos fibers are liberated into the air when asbestos-contaminated wood is burned, but most of the fibers stay inside the ash. So that leads to another study: What happens when you sweep out contaminated ash within the home? We haven't done that one yet."

Ward says this work is important because the EPA has spent millions of dollars cleaning asbestos contamination in Libby structures. He worries that area homeowners inadvertently might undo this work by burning tainted wood.

While working at the Superfund site, the scientists learned that the U.S. Forest Service was doing a lot of work in an area east of the mine. So they shared their initial results with the agency and also collected bark samples.

"They were doing work there unprotected in an area that turned out to have significant asbestos in the trees," Ward says. "After we provided our information to them, they don't go up there anymore unless they are in full personal protective equipment. So we helped prevent exposures to Forest Service workers up there."

The Forest Service also produced an informational brochure for people working and recreating on federal land that warns of asbestos detected in the soil, tree bark and duff surrounding the mine. In addition, in February 2009 the agency moved back the boundary surrounding the Libby Superfund Site that it will allow firefighters to cross to battle blazes. (The agency can still use aircraft to fight fires there.)

What would happen if a big wildfire roared to life among the contaminated trees surrounding the mine, liberating all those asbestos fibers?

"It could be bad news," Ward admits.

The contamination problem goes far beyond Libby, and the researchers have noticed that individual cases of asbestos-caused mesothelioma in Montana cluster around railways. Now they are collecting bark samples along railroad corridors, looking for the telltale fibers. They also intend to sample the bark near the urban processing facilities across the nation where Libby's vermiculite was shipped.

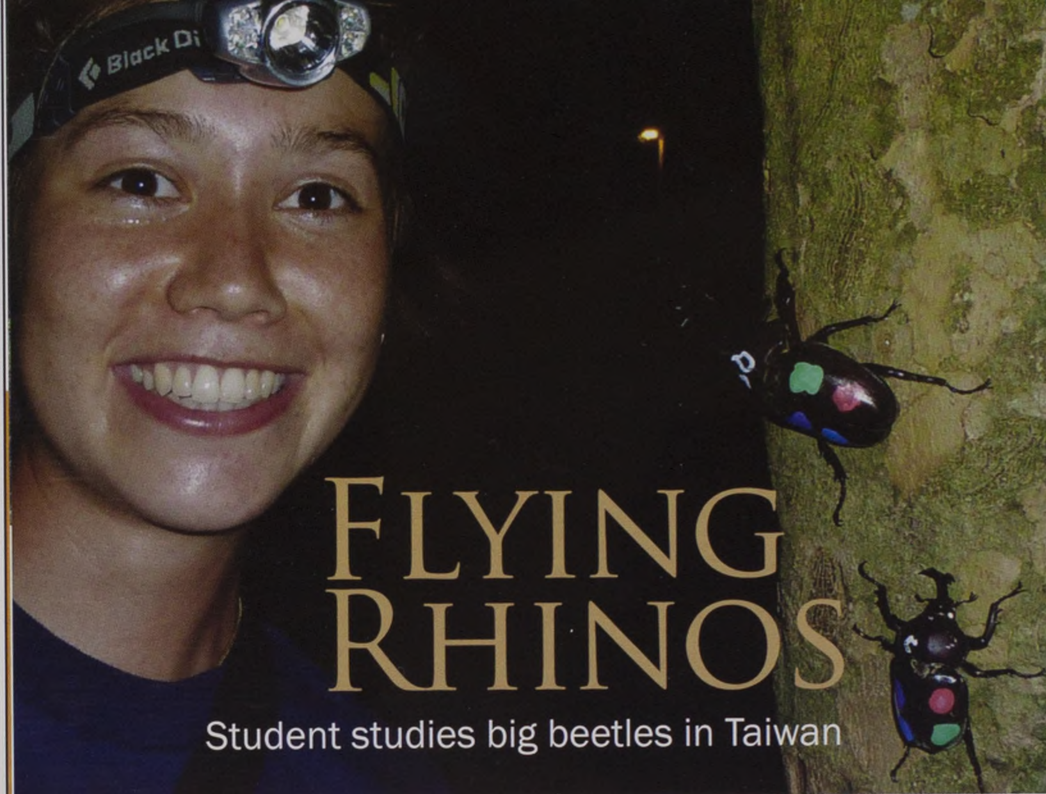
"We hope to discover currently unknown contaminated areas using the new bark procedure," Ward says.

As for the tainted trees near Libby, he suspects the contamination is so widespread around the mine that they might be impossible to cleanse.


UM researcher Tony Ward

"We just have to figure out a way to protect those folks who live there," Ward says. "If you can give them alternative places to get clean firewood, then you eliminate them getting contaminated while harvesting firewood and burning it. We just want to prevent future exposures." V

For more information, e-mail tony.ward@umontana.edu.



Flying Rhinos

Student studies big beetles in Taiwan

Interview by Brianne Burrowes

Erin McCullough, a second-year doctoral student in UM's organismal biology and ecology program, spent last summer studying the Japanese rhinoceros beetle, also known as Allomyrina dichotoma. *Her research, funded by the National Science Foundation East Asia and Pacific Summer Institutes, focused on determining whether there is a relationship between a beetle's horn size and the aerodynamic and energetic cost of flying with horns. For three months she tracked the beetles at two different sites in Nantou County, a mountainous region in central Taiwan.*

What sparked your interest in studying beetles, and more specifically, rhinoceros beetles?

I've been interested in animal behavior for a really long time. As a little girl I used to play in tide pools and just watch birds and squirrels. I've always loved the animal kingdom. As an undergrad I studied navigation and decision-making in honeybees and bumblebees. After I graduated college, I spent a year studying feeding behavior in primates in Thailand. When I was applying for grad schools, I wasn't specifically looking to study rhinoceros beetles but, more broadly, animal signals. I have always been fascinated by how elaborate and bizarre some animals can be. I interviewed at a whole bunch of different schools around the country, and Montana was the last place that I interviewed. I just sort of fell in love with Missoula, and the professors and the program. My adviser, Doug Emlen, has been studying horned beetles for the last 15 years. Only recently has he switched to the rhinoceros beetles. He's done most of his work on dung beetles, which are much smaller but also have really interesting and elaborate horn morphologies.

What was your first step when you arrived in Taiwan?

I wanted to do my research at a field station. Unfortunately, when I got to Taiwan at the beginning of June, there were no beetles. I'm not sure if I was there early. Usually beetles are out by May. The whole life span of a beetle is about a year. They spend most of it as larvae. The adults will emerge in May, maybe even the end of April, and then they'll live through August. The field station is a popular destination among tourists, and the beetles there have been heavily harvested. Tourists will take them home to sell, or kids will take them home as pets. Because of this the population is dwindling. So there I was at the research station with no beetles. I was only in Taiwan 10 weeks, and I couldn't wait around for the beetles to possibly come and then have tourists take them, because my project hinged on the fact that I needed to see beetles over consecutive nights. I needed to know how far they're moving from night to night in order to measure flight distance. If they were getting collected by tourists, this wasn't going to work. I went to National Chi Nan University in Puli, Taiwan, and there was a large population of beetles. This ended up being one of my research sites. It had a large population of beetles that wasn't getting harvested. Then I had a second study plot on the side of a mountain road about four kilometers southwest of campus.

What was the focus of your research in Taiwan?

I'm interested in the aerodynamic and energetic costs of flying with these horns. If you have a big horn sticking on the front of your head, how hard is it to maneuver? How hard is it to turn? How does this differ if you have a horn sticking straight out in front of you or if you have several different horns around your head? I'm interested in how the shape of the horn might affect the way that you fly, so how a horn of one shape might cause more drag than a horn of a different shape, or how the horn of one shape might shift the beetle's center of mass more. The horns can be more than half the length of the body. It would be like humans having a leg sticking out of their head. This is a large appendage. It can be very heavy and, I assume, very awkward. It is likely to cause imposed aerodynamic drag. So, if flying with the horn is costly, I would predict that big males with big horns would fly slower, or that maybe they just won't fly as far or as often.

How did you test your hypothesis?

The beetles are nocturnal. I was active at night. I used headlamps because the beetles are light sensitive. If you are staring at beetles for long periods of time, you don't want to be shining a bright light on them. But they can't detect red light, so I would put red cellophane over my headlamp and then stare at them as long as I wanted. I would find each beetle, and then I would mark them with paint pens. I would give each beetle four dots – two dots on the left elytra (the hard wings on a beetle) and two dots on the right elytra. And, I would give each beetle a number. I then measured the horn length, the horn width, the prothorax width and the elytra length as measures of body size. Then I put the beetle back on the ground, and I would wait for it to take off. Some beetles were ready to go and would take off right away, and some beetles were extremely reluctant to fly. I think I waited three hours for one beetle to take off. Sometimes they just don't want to go. Actually, it's interesting because they are much more eager to fly from 7 to 10 p.m., and then there's a lull from 11 p.m. to 3 a.m. where they don't want to do anything. Then right before the sun comes up, they're ready to go again.

How did you measure flight speed?

I used a radar gun, which is the same instrument that police use to measure speeding cars. The males are fighting on trees over these sap sites and whoever loses gets knocked off the tree, and then they fall down to the ground. Then they take off from the ground and fly back onto the tree or onto another tree. I would use the radar gun and track takeoff speeds as the beetles were coming off the ground, which was much easier than I thought. I started off the trip thinking there was no way that I was going to be able to measure flight speeds. But if I know where the beetle is, and I'm following it, then I can take the speed as they take off easily.

When you clocked their speeds, what was the average speed?

They're going anywhere from 1.5 to 3.5 meters per second. Most of them are going between 2 and 3 meters per second, which is pretty fast. My adviser thought that I could run after them, but there is no way I would be able to run 3 meters per second after a tiny insect in the dark. (Laughs)

How did you measure flight distances?

I did scans every two hours. I had two study plots. At these sites I had all of my trees marked, and every two hours I would scan all of the trees and see which beetles were in which trees. Again I had all of the beetles marked. I would go up and down (the tree trunk) with my big light, and I would see which beetles were on the trees. If there were any beetles that I hadn't marked, I would mark them.

What did your study find?

I actually haven't finished analyzing all of the data, but it looks like there's no difference in flight speeds, which I find surprising. Big males, small males and females are all flying about the same speed. So I'm actually beginning to wonder how costly the horns actually are, which is pretty amazing because these structures are huge, and rhinoceros beetles are a prime example of something with a sexually selective trait. Here's this male with this gigantic horn, and if I find that the horns aren't costly at all, that's a pretty surprising result. But there's a lot of lab work and flight lab work that I hope to do to test that specifically.

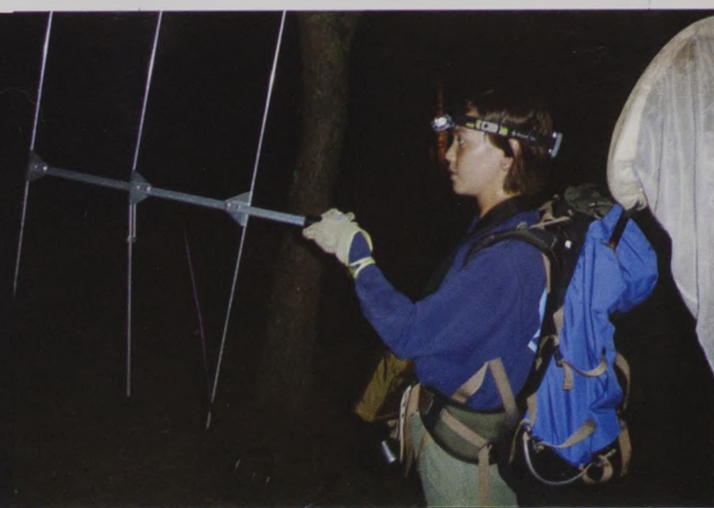
What is next in your research?

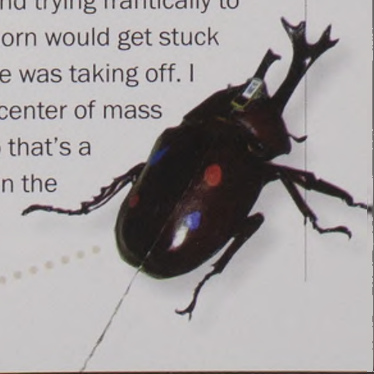
One cost that I want to test is how the horn, or how this big structure on your head, might change your center of mass. The reason I want to test this is because when the beetles were taking off more than once, I saw a male try to take off and his head would run into the ground. His horn would get stuck in the ground. Sometimes he would just sit there with his head in the ground trying frantically to take off, or the horn would get stuck in the vines as he was taking off. I really think that center of mass seems costly. So that's a next step that's in the near future. ◼

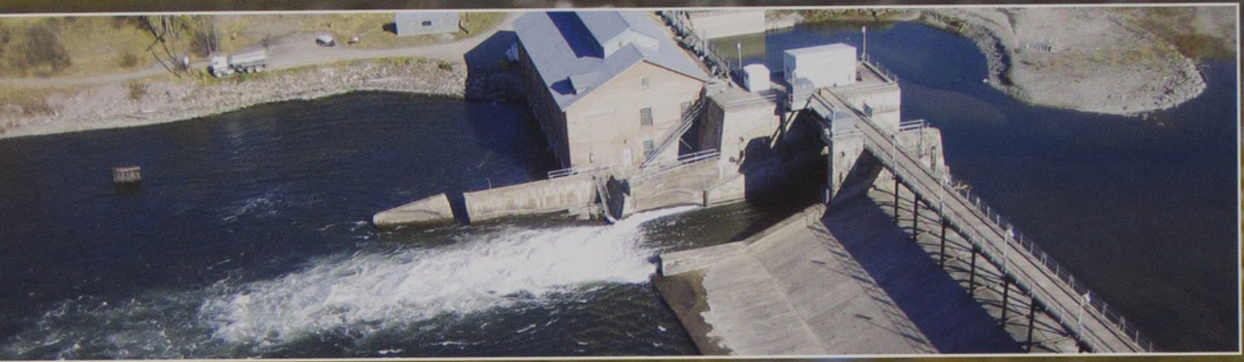
(Opposite) UM doctoral student Erin McCullough, working in Taiwan, poses with two rhinoceros beetles she had marked with paint pens.

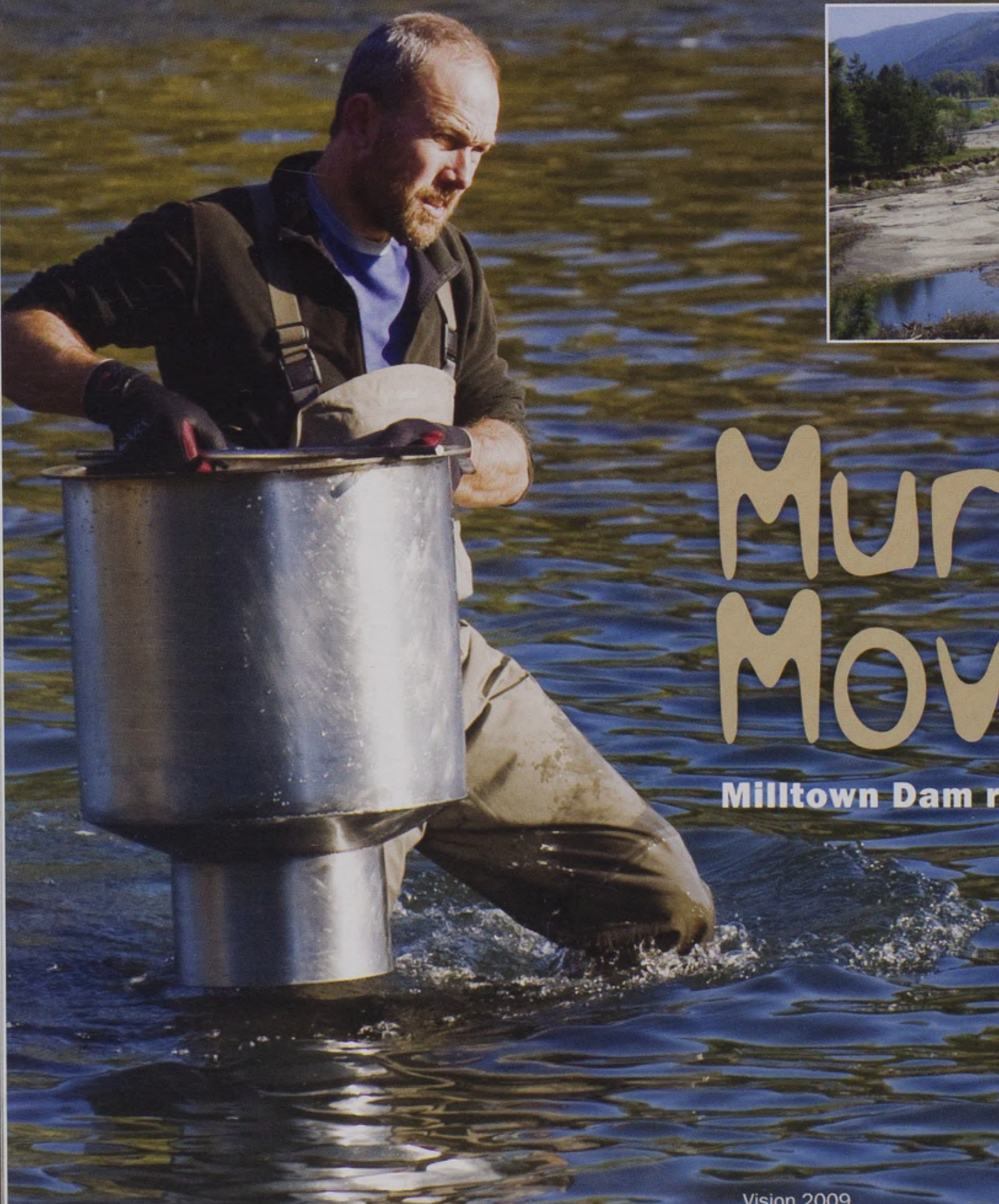
(Left) Powerfully strong for its size, this beetle has no problem carrying the transmitter attached to it.

(Right) McCullough and some of the specialized equipment she used to track the beetles at night







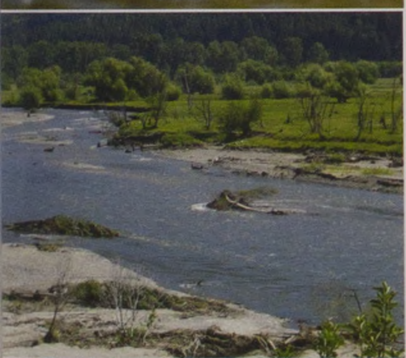


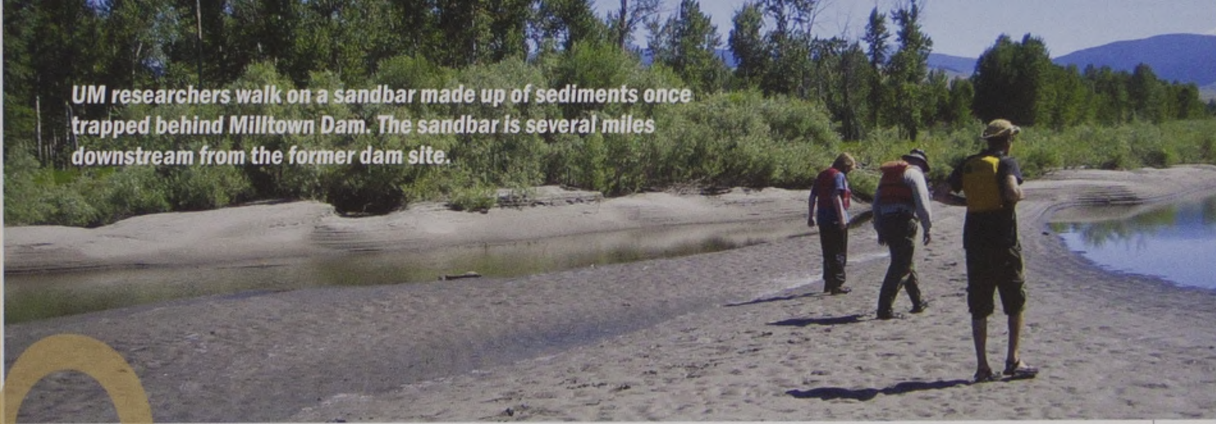
Murky Movement

Milltown Dam removal releases sediments

By Patia Stephens

(Background photo) UM geosciences Assistant Professor Andrew Wilcox carries a McNeil sediment sampler through the Clark Fork River west of Reserve Street in Missoula. Wilcox has observed widespread deposition of sediment released by the removal of Milltown Dam in that stretch of river. (Top inset) Milltown Dam was built in 1907 by copper-mining tycoon William A. Clark to supply hydroelectricity to his sawmills in nearby Bonner. The dam trapped nearly 6 million cubic yards of contaminated sediment from upstream mining activity. (Middle inset) A coffer dam side channel is breached in March 2008, allowing the Clark Fork to flow freely past Milltown Dam for the first time in a century. (Bottom inset) This area of Milltown Reservoir, which is upstream from the dam removal, shows effects of river erosion.





UM researchers walk on a sandbar made up of sediments once trapped behind Milltown Dam. The sandbar is several miles downstream from the former dam site.

On his faculty Web site, Assistant Professor Andrew Wilcox recruits prospective students with the following quip: "The University of Montana is a fantastic place to study river systems. ... Montana also has great geography for studying rivers – there are a lot of nice ones around here, and some screwed-up ones, too."

It's a humorously apt description of a place that has both some of the most pristine bodies of water in the world and some of the most polluted, thanks to its legacy of resource extraction.

The Clark Fork River, named for explorer William Clark, is the main drainage for Western Montana's northern Rocky Mountains and a main tributary of the huge Columbia River. The Clark Fork and its own main tributary, Silver Bow Creek, are recovering from a century of mining for copper and other metals in Butte and Anaconda. In 1908 a massive flood flushed millions of tons of mining and smelting waste down the two waterways. These heavy-metal residues – mainly arsenic, cadmium, copper, lead and zinc – traveled more than 100 miles until they hit Milltown Dam. The dam had been built only a few months earlier at the confluence of the Clark Fork and Blackfoot rivers just east of Missoula. There the toxic sediments stayed – most of them, anyway – earning the 120-mile stretch between Butte and Missoula the dubious honor of being the nation's largest Superfund site.

The Clark Fork River Superfund Site was established in 1983 after dangerous levels of arsenic were discovered in Milltown wells and traced to sediments that had collected in the 180-acre reservoir behind the dam. Two decades later in April 2003, the U.S. Environmental Protection Agency and the Montana Department of Environmental Quality issued a plan recommending removal of Milltown Dam. The plan also called for removal of approximately 2.2 million of the 6.6 million cubic yards of contaminated sediments in Milltown Reservoir. After thousands of public comments, the EPA's proposal to remove the dam and sediments was finalized in December 2004.

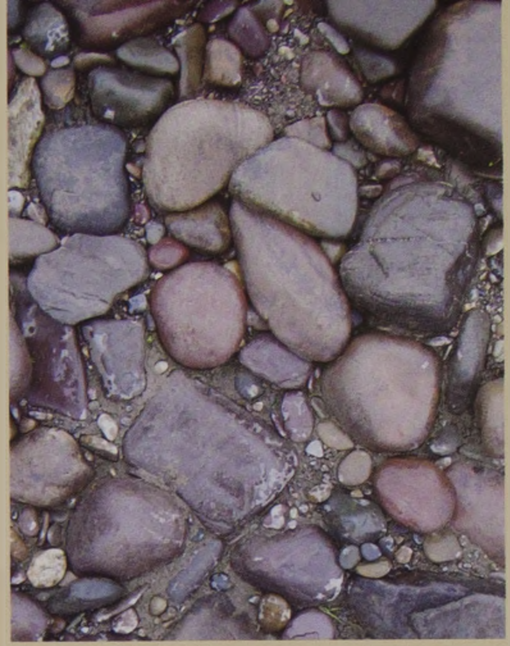
A railroad spur was built to haul the sediments back upstream for disposal at Opportunity Ponds near Anaconda, and excavation began in October 2007. When Milltown Dam was officially breached in March 2008, the Clark Fork and Blackfoot rivers flowed together unimpeded for the first time since the 100-year-old timber crib dam was built. While more than 2 million cubic yards of the most contaminated sediments have been removed, that leaves some 4 million behind. Where will the sediments go? How much has been flushed downstream since the dam was breached? How will it affect the river and its denizens, both in the short and long term?

Those are questions Wilcox and his students have attempted to answer. Wilcox, who researches and teaches in UM's Department of Geosciences, is a fluvial geomorphologist, meaning he studies river flow, sediment transport and channel evolution. He arrived at UM in August 2007 just in time to cobble together a few small grants and begin studying the removal of Milltown Dam. He received another, larger grant of $180,000 from the National Science Foundation in summer 2009.

Across the country, dam removal is a relatively new and burgeoning industry, and the science surrounding it is in its infancy. In the West, at least eight dams are scheduled for removal in coming years, and debates are under way concerning others. Removal of Montana's Milltown Dam and its contaminated sediments is the biggest project of its type ever undertaken. Wilcox hopes information gleaned from the project will help inform discussion, planning and execution of other dam removals.

"When tens of millions of dollars are being spent on sediment removal from Milltown," Wilcox says, "we can see why having better tools for modeling and predicting sediment transport is important."

Wilcox has had no trouble recruiting undergraduate and graduate students from the geomorphology classes he teaches to work on the research project. Together, they've used sampling devices suspended from bridges on the Blackfoot and the Clark Fork to capture sediment flowing into and out of the reservoir. The researchers have measured channel and sediment depths and collected sediment samples from the riverbed and banks between the dam and where the Clark Fork joins the Bitterroot River west of Missoula. They've collaborated with UM geochemistry Professor Johnnie Moore to measure heavy metal content in the sediments, allowing them to "fingerprint" the source of downstream deposits based on their geochemical signature.



(Top) Sand and silt formerly trapped behind Milltown Dam has filled in the spaces between these downstream river rocks.
(Bottom) A bedload sampler is dangled into the Clark Fork River to capture the sediment flowing downstream.

Wilcox's sampling, combined with measurements by the U.S. Geological Survey, reveals that hundreds of thousands of tons of sediment have moved through the gap – far more than anticipated. An initial large "pulse" of sediments occurred after the breach in 2008, followed by a smaller pulse during this spring's high-water event. Some of the sediment has contained heavy metals. Much of it has been deposited, at least temporarily, along the riverbed and banks of the Clark Fork – especially where the river slows and spreads near Kelly Island, west of Missoula's Reserve Street and the city's levees. Some of the sediment, presumably, has traveled more than 100 hundred miles downstream to settle behind the next major obstacle – Thompson Falls Dam.

With so many organizations involved in facets of the dam removal – the Environmental Protection Agency; the Department of Environmental Quality; UM; Fish, Wildlife & Parks; Envirocon; Atlantic Richfield; the Clark Fork Coalition; and private monitoring consultants, to name a few – there's bound to be some controversy. Wilcox wrote a guest editorial for the Missoulian last November to reject a statement about the Clark Fork's water quality that was incorrectly attributed to him.

"I am not a toxicologist," he wrote. "I would not make human health recommendations." In his opinion piece, and again in this interview, he said the EPA has found that the Clark Fork's water quality is within health standards. "My students and I spend a lot of time in the Clark Fork. I'm not concerned about our health."

Wilcox is more concerned with the sediments' effects – negative and positive – on the riverbed and the creatures that live in it, such as the threatened westslope cutthroat trout and bull trout.

"Even if the sediment doesn't have contaminants, it could have effects like suffocating the gravels that fish spawn in," he says. "That is the most significant effect we've seen on the river. The space between rocks where bugs and juvenile fish hang out has been filled with sand and fine sediments."

But that development may be temporary – and to a certain extent, it may also be natural.

"Rivers need sediment," he says. "A river bed without sediment is coarse and 'armored' – static and locked into place.

"We know that this dam removal will create long-term benefits to the river by restoring natural processes and habitat – allowing sediment to move and fish to migrate. Part of what makes rivers natural is that they are dynamic. They erode their banks. They erode their beds. They move from side to side."

Wilcox's research also has shown dramatic changes to the Blackfoot River, the revered stream made famous by Norman Maclean's book "A River Runs Through It." Sediments deposited in the lower Blackfoot by dam backflow already have been flushed out, restoring riffles and pools to the river after a hundred years without them. Now the fish that can once again migrate upstream from the Clark Fork to the Blackfoot have a more natural habitat to welcome them.

Where policymakers and the public might prefer a sure thing, Wilcox takes the view of a scholar and scientist.

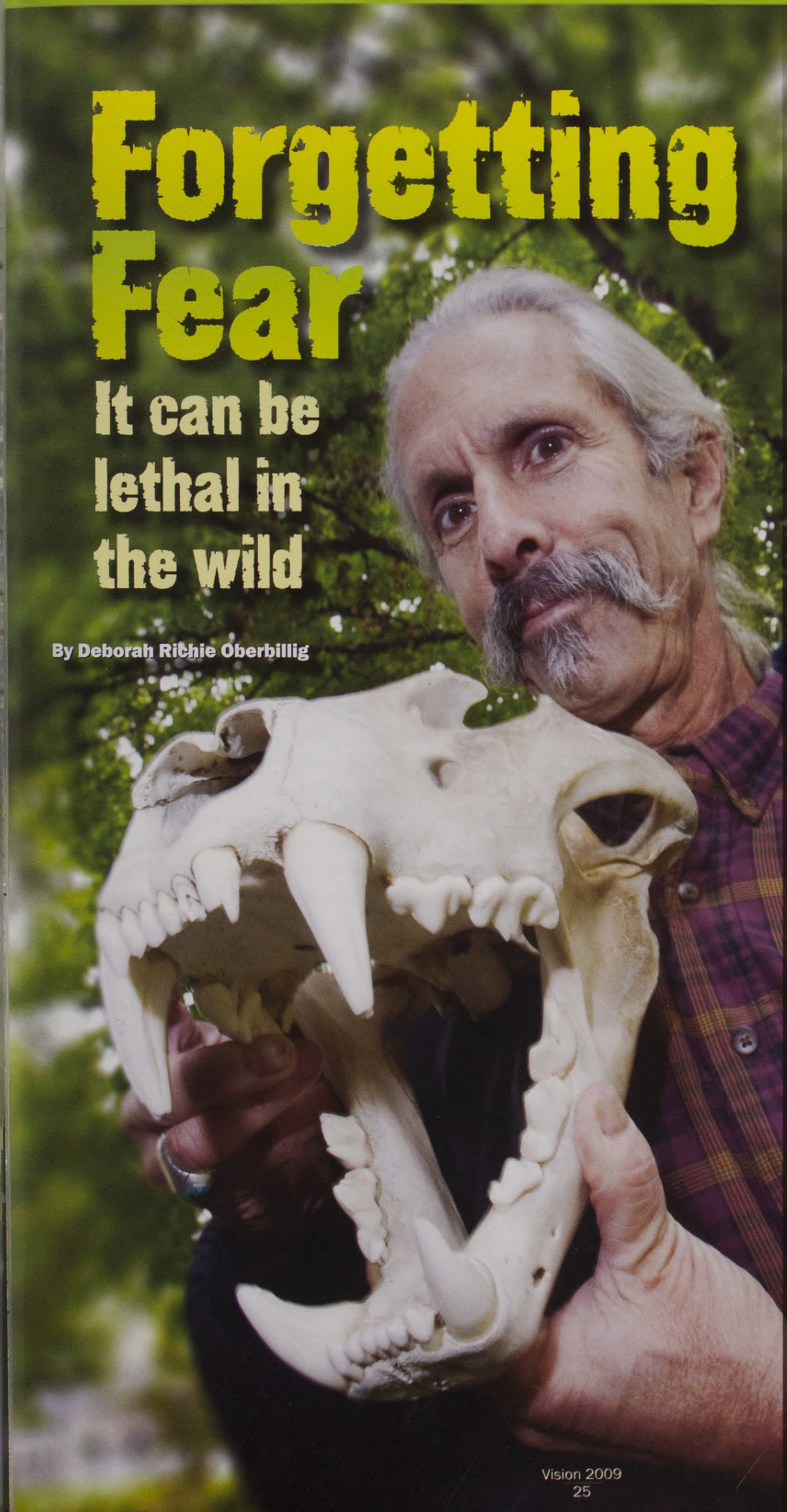
"Removing dams is an experiment," he says. "There's a lot we don't know and a lot we can learn. We need to embrace uncertainty and be open to learning." V

For more information, e-mail andrew.wilcox@mso.umt.edu.

Forgetting Fear

It can be lethal in the wild

By Deborah Richie Oberbillig



In Montana's grizzly country, hikers call out, "hey bear!" as they round each bend. Backpackers hang their food from trees and sleep with senses attuned to rustles and snapping twigs. Similarly, in a city known for crime, people avoid walking down dark alleys. They double lock doors and install alarm systems.

"No matter where you are, there's something to fear," says Joel Berger, UM's John J. Craighead Chair, professor of wildlife conservation and a senior scientist with the Wildlife Conservation Society. Fear is a common denominator among humans and wild animals alike, affecting behavior and culture.

His 2008 book, "The Better to Eat You With: Fear in the Animal World," reads like a thrilling adventure tale in forbidding winter terrain ranging from Yellowstone and Alaska to the Russian Far East and Mongolia. Here's a passage about reading the collar number on a protective mother moose as part of his research in the Tetons:

"Suddenly, a huge dark object rushed me. Her speed was explosive; ears were down, nape hair fully pilo-erect. Light momentarily reflected from an object on her neck. *Ahh, the collar – number zero, one zero."*

Yet, woven throughout such hair-raising escapades are scientific questions whose answers Berger

The better to eat you with: UM researcher Joel Berger, shown here holding a lion skull (one of many predator skulls decorating his office), studied the wolf reintroduction to Yellowstone National Park and Grand Teton National Park and how moose had to relearn their fear of the carnivores.

hopes will improve our ability to restore missing predators to ecosystems and to save animals from extinction. For more than a decade, Berger investigated these four inquiries:

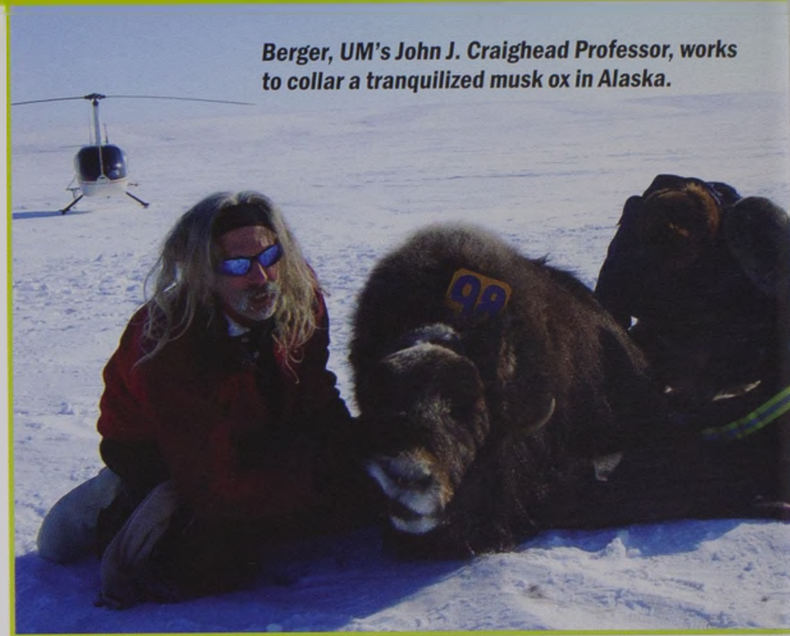
1. **Do prey species remember their enemies?**
2. **If they don't, how do they learn about them and avoid extinction?**
3. **Is there a culture of fear?**
4. **How do we take the answers to the first three questions and do more for conservation?**

Berger started assessing fear as a behavioral trigger 18 years ago when he lived in Africa studying rhinos and sharing an adrenaline-filled life in the bush with his wife and their 19-month-old daughter, Sonja.

"When it was time to come back to North America, I thought about what questions would be useful to ask that would build on my work in Africa," Berger says. He readily admits that he also was looking for exciting research to rival his time among rhinos, lions and hyenas.

"Most scientists use the lab, but for me my lab is everywhere," says Berger, who today has a bit of the look of a classic 19th-century explorer, complete with mustache and flowing long gray hair. Not surprising, his search took him straight to Yellowstone National Park and the Grand Tetons, where plans were under way in the 1990s to reintroduce wolves. The perfect experiment unfolded: a predator-prey study before and after their return. How would the elk, moose and bison react?

"People were concerned that if you put predators back in a system, the prey would be blitzed because they wouldn't know how to respond," Berger says. He focused on the reaction of prey and soon realized he needed to look beyond Yellowstone to seek answers. Berger chose four species: elk, moose, bison and caribou. In each case he was able to pinpoint comparable landscapes where these animals lived with and without wild predators.



Berger, UM's John J. Craighead Professor, works to collar a tranquilized musk ox in Alaska.

To study elk with predators, he headed to the Russian Far East, where Siberian tigers hunt for wary elk (called red deer), as well as moose. In Alaska, he investigated both moose and caribou that proved to be quite savvy to wolves. In Greenland, he tracked caribou without predators that showed no sense of fear, and in far northern Alberta's Wood Buffalo National Park, he pursued bison that were preyed on by wolves.

He'd found his dream job – tracking animals that could devour or trample him in far-flung landscapes with subzero temperatures. They also were places of rare beauty that Berger records in passages such as this one about the Kolumbe River Basin of Siberian Russia: "I walked on moist tussocks and entered a thicket where water ran powerful and clear. I filled my water bottles. The air was soft and the light gentle. A kingfisher flashed past."

Into such realms, Berger lugged tapes and a machine to play the calls of ravens, howler monkeys, hyenas, lions, tigers and wolves. He added the sound of running water for good measure. Sometimes he enlisted field assistants to help note the reactions of prey – lifting heads, length of vigilance, no reaction or fleeing.

Certain results proved surprising. The bison in Wood Buffalo National Park barely blinked when wolf howls were played, but when the shaggy beasts heard lion roars they raised their massive heads, as if registering a sound from their Pleistocene past. Berger cannot be sure if that reaction stemmed from the acoustic quality or from the bison's ancestral connection.

Moose in Alaska grew watchful when hearing the croaks of a raven, a bird closely associated with wolf packs. If he hit the wolf howl recording, they fled. However, the Teton moose prior to wolf reintroduction showed no reaction to either wolf howls or raven croaks. When wolves did return to the Yellowstone ecosystem, the elk and moose initially did not register instinctive fear. The wolves trotted up to elk and moose as easily as tourists snapping photos of the big animals on the roadside. But fear soon set in. Elk as herd animals passed that information horizontally to one another, whereas the solitary moose translated fear vertically to the next generation, their calves.

While bison remained oblivious to Berger's wolf howl playbacks in Yellowstone before and after wolf reintroduction, that does not mean they were not aware or changing behavior, he says. Overall, the results of his long-

After decades without wolves, moose in the Yellowstone and Grand Teton national parks needed to rediscover their fear of the pack hunters.

When wolves were first reintroduced to Yellowstone National Park, they trotted up to elk and moose as easily as tourists snapping photos of the big animals on the roadside. (Wildlife photos by Joel Berger)

term study point to Yellowstone's prey forgetting their predators, but fairly quickly learning about them. The culture of fear appears present, too, as elk and moose modified and passed on their fear-driven behavior. Berger notes that now moose in the Tetons have learned to stay closer to roadsides as safer zones from grizzly bears. Armed with this knowledge, how does fear then play a role in conservation?

"The behavior is fun to observe, but it is more than just fun," Berger says. "What we find out about by being on the ground and by watching animals is that we have a chance to get to the table." That table is wildlife conservation – adding behavior into the mix when assessing survival of offspring, causes of mortality and critical habitats to protect.

"Look at exotic species," Berger says. "If the prey haven't evolved with these introduced predators, they can't avoid them."

Apparently, wildlife that lack ancestral connections to a predator often fail to learn how to survive when confronted with a never-before-known enemy. The trail of destruction ranges from introduced red foxes destroying native fauna of Australia to the non-native brown tree snake wiping out birds in Guam. In the past 500 years, more than 80 percent of mammal extinctions were on islands where species had little knowledge of predators.

"Innocence can be fatal," Berger writes in his book.

The lessons he sees for conservation? Look to the ancestral past as well as to the present and add fear-based behavior into the equation when planning to save species and restore ecosystems by returning a missing predator.

"The way of the world is to lose the large carnivores, not to add them," Berger says.

But in the restoration of wolves to Yellowstone he sees both a success story and hope for the future. Indeed, hope appears to guide Berger's work as a wildlife professor and researcher.

Today, he pursues musk ox in Alaska's Arctic, "trying to get a better handle on whether they can persist with climate change." His other quarry is the saiga, a swift and endangered mammal of Mongolia that is the ecological equivalent of the pronghorn. Berger's fieldwork on pronghorn in Wyoming played a key role in a conservation initiative, "Path of the Pronghorn," aimed at preserving a long migration corridor between Grand Teton National Park and winter range in the Green River watershed. The future of the rare saiga hinges on a similar need to conserve its migration route.

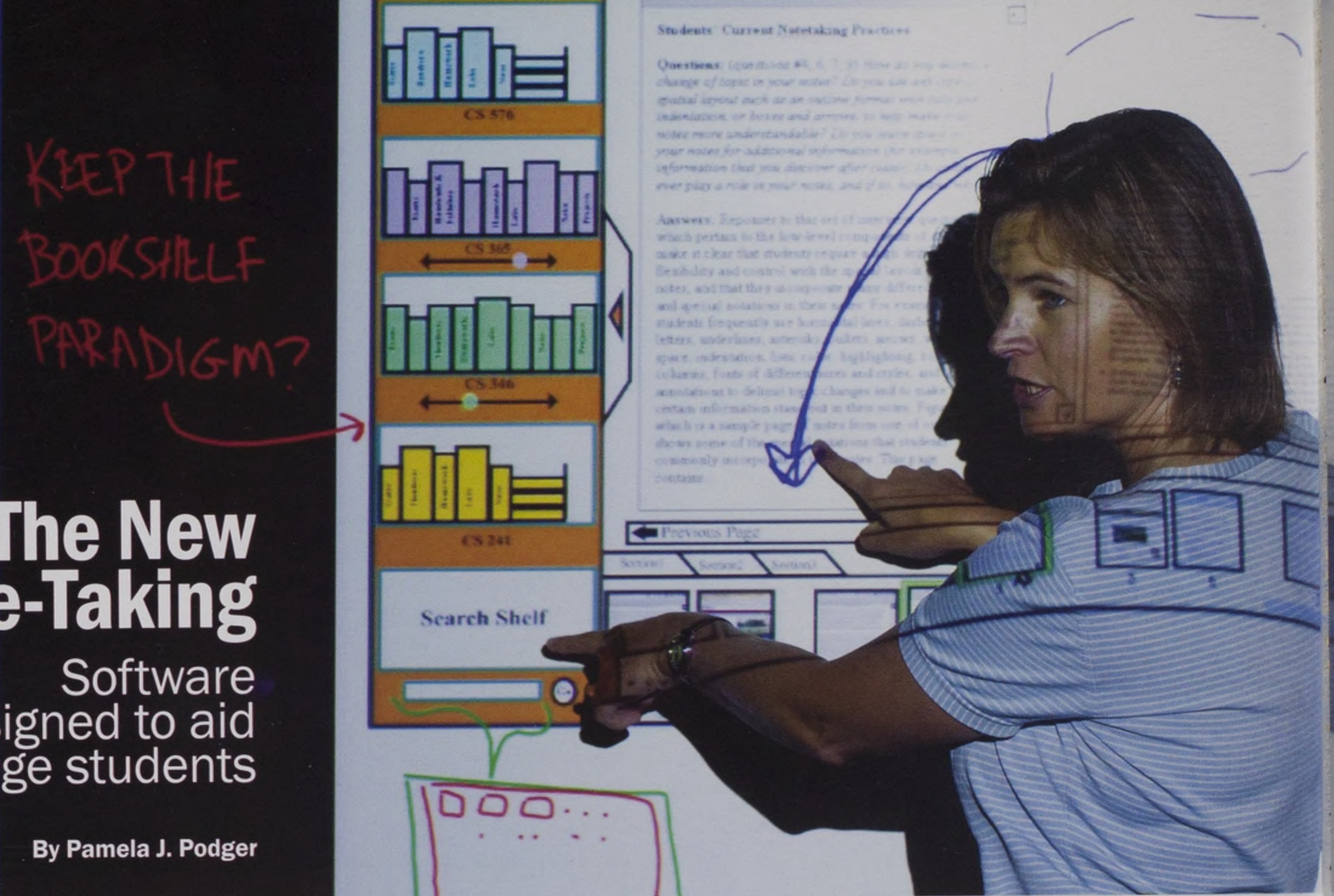
Berger is UM's first John J. Craighead endowed professor in wildlife biology, appointed to the prestigious chair in 2007. Craighead, now in his 90s and living in Missoula, remains a giant in the field of both research and conservation. He and his twin, Frank, set a high standard for combining field research, cutting-edge technology and communication to conserve wildlife around the globe – from grizzlies to birds of prey. John Craighead led UM's Montana Cooperative Wildlife Research Unit for 25 years.

The endowed chair was made possible by many donors to the University's "Invest in Discovery" campaign and championed by the unrelenting efforts of Dan Pletscher, director of UM's Wildlife Biology Program. Berger arrived with an impressive portfolio. He's the author of five books and more than 100 peer-reviewed articles. He spent seven years as senior scientist for North American programs for the Wildlife Conservation Society in New York City, following a long career based at the University of Nevada, Reno.

Berger joins equally accomplished UM colleagues known for globally significant research, yet firmly anchored in this region and committed to their students. As you might imagine, when you put them together in one room sharing investigations, questions and solutions to conservation crises, the atmosphere nearly sparks with electricity.

"The University of Montana is unquestionably the best place to be if you're interested in conservation biology," Berger says.

For more information, e-mail joel.berger@mso.umt.edu.



The New Note-Taking

Software designed to aid college students

By Pamela J. Podger

Today's students manage a digital life as software and Internet research augment the traditional texts, handouts and notes they use in the classroom.

For example, one professor expects his students to stay current by accessing their assignments in Blackboard. In other classes, students are expected to learn Excel, Adobe Photoshop and an array of other computer applications.

Yolanda Reimer, an associate professor in UM's Department of Computer Science, is attuned to this trend. She says help is on the way for students who juggle course work while learning to master the technology in their lives.

"One of the fascinating things in this day and age is how rapidly things are changing and how students are impacted," Reimer says. "Students have so much information to manage and incorporate from many resources. We want to help them integrate technology in the most beneficial way."

This fall Reimer will do additional testing on her new software called Global Information Gatherer, or GIG, in a UM classroom. Her research on student note-taking and information management is funded by a $500,000, five-year National Science Foundation Faculty Early Career Development Award.

Reimer says GIG is a "wrapper or container program" that allows students to manage several applications simultaneously, permitting them to open Word documents, drag and drop materials, take notes, launch PowerPoint presentations, view PDFs and conduct Internet research.

"This software makes it one seamless interaction," Reimer says. "We know when students have to transfer their focus between multiple windows, it interrupts the flow of their work."

Reimer has published four papers on the design and development of GIG already. She says more upcoming classroom evaluations of her software – most likely done in a computer science, business or humanities class – will provide additional feedback and help her continue to refine the work she first launched at UM in 2002.

"My work really focuses on the end user of a computer program," she says. "No matter how fast or glitzy the computer application is, it isn't helpful if people don't use it. We try to build in feedback early in the process so changes are cheaper and more efficient."

Reimer, who did her master's work at UM, says her current efforts springboard from her doctoral research at the University of Oregon, where she studied how geneticists conduct Web-based research, record notes and store information. Her initial research at UM builds on her dissertation. She says the early versions of GIG were sketched out and evaluated before evolving from low-fidelity prototypes to a more robust, stand-alone application.

Together with her graduate research assistants, she evaluated early versions of the prototype by asking students to perform tasks on the GIG system, videotaping them and observing where they got stuck, befuddled or confused.

"Historically, human-computer interaction has been marginalized," she says. "But our belief is that consideration of the end user needs to be fully integrated into the design process instead of being tacked on at the end."

From 2005 to 2007, Reimer and several graduate research assistants conducted a number of different user studies on how students manage information.

Their efforts included about 70 interviews, followed by a broad-based questionnaire that targeted more than 280 students majoring in a variety of subjects. In another study, they followed the students around campus for part of a day to see how they took notes and managed their information on a daily basis.

Reimer says her early findings confirmed what she and several graduate assistants had suspected: Students are deeply immersed in technology and many own computers, but most still rely on hand-written notes.

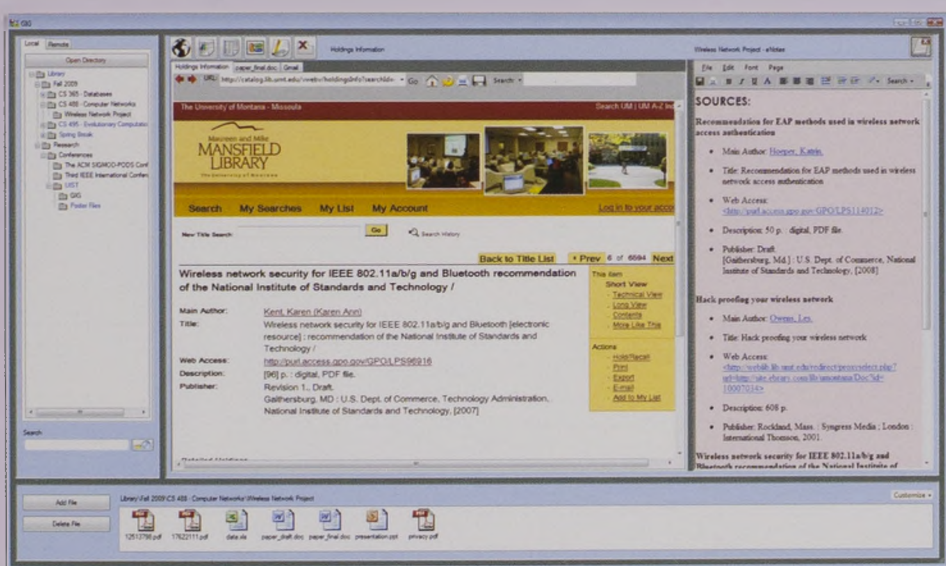
She says the students, even the most tech-savvy, readily cited many of the values commonly associated with hand-written notes. These include portability, flexibility and visual cues – such as doodles or coffee rings – that can help students remain oriented. Many of the students also believe that hand-written notes strengthen and improve their memory of the material.

While electronic notes often are faster to write and organize, hand-written notes also allow students to draw diagrams quickly or add comments in the margins.

This leads Reimer and her team to several conclusions.

"We determined that if we build students software, we should assume it wouldn't replace their hand-written notes," she says. "Instead, we should design something that complements these notes."

Reimer says the students they contacted were interested and receptive to help but also had concerns. They worried the electronic notes would crash, and they needed assurance that such a system would be secure. They also expressed an interest in the ability to store and access their notes from a centralized location, because they moved about campus on a regular basis.



(Above) A screenshot of Global Information Gatherer, which allows students to manage several applications simultaneously. (Opposite) Yolanda Reimer, a UM computer science associate professor, uses a SMART Board to highlight the features of a prototype version of her Global Information Gatherer software.

"What we reaffirmed in our minds is that students are very mobile and use a lot of different devices," Reimer says. "So they develop their own solutions to any problems they encounter. For example, they might e-mail notes to themselves so they can access them anywhere and save the information."

She says the feedback they gathered helped in the design of a system that would enable students to better manage their digital information.

In the initial five focus groups – each comprising 14 users – Reimer had students critique a prototype design using a SMART Board as the display device, asking them to share and illustrate their own design ideas.

Reimer also had students in her user-interface design course help evaluate the software. In fall 2006 she gave students the challenge of developing their own note-taking program. Later in her spring 2009 class, a more fully developed version of the computer application was tested and critiqued by students.

"We didn't limit them to certain tasks," she says. "We asked them to generally tell us what they liked and did not like about the software and how they used it."

The outcome is a more useful version of GIG, which is a note-taking system as well as a computer application that helps students gather information and organize research and assignments.

Peter Wolf, a graduate student from Whitefish who has assisted Reimer, says testing GIG on students– both computer science majors and others – is vital. He says computer science students literally have a goal of "breaking" the program – finding its faults and limitations.

"When we rolled GIG out to the computer science class, they were very responsive," Wolf says. "We also need to test it to see the pitfalls for a typical user. How would they use it? View it? Install the software? It is going to be really interesting to get a different view from students who don't know how the coding and programming works."

Reimer says the initial evaluation from computer science students who tested GIG ranged from major changes to lesser revisions. The students' suggestions included improving GIG's embedded browser to include tabbed browsing to smaller comments about the location and size of interface buttons. Reimer says GIG currently is designed for Windows-based computers and not mobile devices.

She finds the work exciting and important.

"We need to continue trying to understand if and how the fundamental process of note-taking is changing and evolving in the digital age," Reimer says. "We need to figure out how to provide students with the tools they need to maximize their academic potential." V

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Lost Meanings

By Jesse Froehling

UM scholar reveals Constitution's original intent

What they really meant: UM law Professor Rob Natelson has become a leader in the field of trying to unravel the true intent of the Founding Fathers when they wrote the U.S. Constitution.

In 1942 during World War II, President Franklin Roosevelt sought to protect the U.S. by interning the country's Japanese-Americans. Ten years later, President Harry Truman crushed a strike when he ordered the Secretary of Commerce to seize the nation's steel mills. After the attacks of Sept. 11, 2001, President George W. Bush stashed suspected Islamic militants at Guantanamo Bay, Cuba, and denied them habeas corpus. To justify the action, Bush's lawyers, as had the lawyers for the Truman and Roosevelt administrations, pointed to the backbone of U.S. law – the Constitution.

The lawyers concluded the first sentence of Article II, Section 1 – "The executive power shall be vested in the President of the United States of America" – gives the president broad authority to do whatever necessary to fight the war on terror beyond the enumerated powers listed later in the document.

"It's actually a very common claim," says UM law Professor Rob Natelson. "Ever since the founding, presidents and their supporters have argued that, in addition to the enumerated powers, that sentence gives them broad authority."

The question then is what exactly does that first sentence in Article II, Section 1 mean? To answer that, Natelson says, you must look to the past, specifically to 18th-century law.

Digging Into The Past

Natelson speaks precisely and carefully but grows excited easily, hopping to his feet and fishing out a handful of change to illustrate the Constitution's coinage clause. Never is he more animated than when discussing the past. In fact, Natelson's small, tidy office in the UM law school is a testament to history. The Ten Commandments hang on the wall above his computer desk, and the Magna Carta, one of the Western World's greatest legal documents, hangs near the doorway in a place of prominence. The walls also boast a family picture, including the three daughters whom he speaks to at home in Latin.

Natelson's infatuation with history is more than just a personal interest. He says when analyzing a legal document, it's always standard procedure to apply the meaning that the authors ascribed to it. The U.S. Constitution, he points out, is a legal document. As such, the root of its correct interpretation lies in the intentions of the people who created it. By examining the world in which the founders lived, Natelson says, lawyers and legal scholars can answer questions that have plagued the nation's legal system for 200 years.

Natelson has emerged as a leader in the field of study called Originalism, which argues the Constitution has a fixed meaning that was established at the time of its drafting. He's recognized as a national authority on the framing of the Constitution, and his work has appeared in the nation's most prestigious law journals. Academics have cited his work in publications such as the Harvard Law Review, the Yale Law Review, the Michigan Law Review and the Georgetown Law Journal. In many cases, he's been the first to discover the meaning behind the Constitution's apparently ambiguous clauses.

"Probably my biggest contribution has been to bring back to general notice the scope of 18th-century law," he says. "Most of the founders who actually put the pen to paper were lawyers. They had practiced law on Main Street, served in the legislature, been attorneys general. Some were judges. Quite a number had gone to England for education."

In 2005 Natelson followed the founders' footsteps to England. He visited London's Middle Temple, one of four institutions called "Inns of the Court" that traditionally have trained English barristers. Some of the Americans who signed the Declaration of Independence and adopted the Constitution were former students of the Middle Temple. Natelson dug through the library there to find texts studied by the founders – men such as John Dickinson and Edward Rutledge.

"People understand that John Dickinson went to the Middle Temple, but they never take the next step to ask what effect his scholarship had on his legal education," Natelson says. Natelson's approach is "to reintroduce in constitutional writing evidence that the founders found commonplace but has passed away with time."

The first order of business, he says, is immersion in the founders' world.

"You look at the kind of books that they read," he says. "Greco Roman classics, the Bible, English and European history – especially English constitutional history. And also you look at colonial experience. The Revolutionary War experience, what is the colonial experience with Britain? You look at notes taken by delegates during the Constitutional Convention, so you can see why things were put in, why they were taken out." The list goes on.

Originalism Revival

Originalism fell out of legal fashion for a while, Natelson says, and there are several reasons why. First, Natelson notes, the quality of research has been bad.

"Historians are not legal scholars, legal scholars are not historians and few of either are classicists," he says. "My research method is more like those of a historian than a lawyer, because I'm trying to unearth the truth rather than merely build a case. But I have the advantage of legal training and 11 years in law practice, which enables me to place the historical materials in a legal context. I also have some classics background, which allows me to better understand the founding generation's use of English and Latin, as well as their general mindset."

Another reason the legal scholars began to ignore history is because, "If you don't read Latin, you don't get very far in 18th-century law," he says. The last reason involves the mentality with which lawyers read law. Take the Guantanamo lawyers for example, Natelson says. They already had a conclusion in mind about habeas corpus.

"Instead of investigating the issue impartially, lawyers on both sides tended to scour the historical record, often not very effectively, to find evidence that supported their pre-established positions," he says. "The research resulted in confusion, some of which manifested itself in the majority, as well as the dissenting opinions of Boumedienne v. Bush," the landmark Supreme Court decision that granted habeas corpus to enemy combatants in Guantanamo Bay.

"In looking for evidence to support their positions, those lawyers with advocacy roles were only doing their job," Natelson says. "Unfortunately, many law professors and other constitutional commentators have tended to do the same. I see my role as an academic differently."

The legitimacy of our government and public officials depends on the Constitution, which is the stated basis for our federal government.

Besides its landmark status, Boumedienne marked a return to Originalism, a notion that pleases Natelson. While researching the historical facts surrounding the decision, Natelson stumbled upon documents that helped to answer a larger question: Did President Bush have the ability to set up tribunals in the first place? What is the executive power of the president of the United States? Does the first sentence of Article II of the Constitution convey a broad, undefined mass of executive power?

"I came up with a rather clear answer," Natelson says. In an article to be published soon in the Whittier Law Review, Natelson expands on his conclusion.

"Lawyers are creatures of habit," he says. "They tend to draft documents according to certain patterns or formulas."

Natelson checked numerous 18th-century documents that, like Article II, granted enumerated powers. His goal was to find drafting patterns to see what interpretation of Article II fit those patterns.

Natelson found that legal documents frequently include a passage near the beginning that merely identifies the person to whom the document grants powers. Further down the document lists those powers. But insofar as he could find, the documents almost never began with a general grant of broad, unidentified authority, then address other matters before returning to enumerate specific powers.

"What this suggests is that the first sentence of Article II is not a broad grant of kingly executive authority," he says. "The sentence merely tells the reader that the title of the chief executive will be the president of the United States – nothing more."

In other words, Presidents Bush, Truman and Roosevelt were wrong when they asserted that Article II granted them powers other than those listed elsewhere in the Constitution.

Hidden Meanings Unmasked

Along the way to this conclusion, Natelson discovered something else that, to his knowledge, everyone else had overlooked – the close connection between the Constitution's sections on the presidency and the documents by which the British crown had empowered governors in the American colonies.

"In 11 out of the 13 colonies, the governors were appointed from London," he says. "Somebody was designated to be governor of, say, North Carolina. He would get a document called a commission, and then he'd get a set of instructions. What's really striking is that when you look at Article II of the Constitution, and then you look at a commission, you can see a lot of ways that Article II is just a stripped-down version of a commission, with an instruction or two added.

"So colonial commissions may offer us some real insight into interpreting some parts of the Constitution," Natelson says, "but up till now no one writing about constitutional law seems to have noticed."

Despite its ability to flush out answers to some of the legal system's oldest questions, Originalism hasn't always translated well to the present day. Take, for instance, the issue of impeachment. Section 4 of the Constitution's Article II stipulates the ways in which a president may be removed from office: "The President ... shall be removed from Office on Impeachment for, and Conviction of Treason, Bribery, or other high Crimes and Misdemeanors."

Most of the clause, Natelson points out, is rather self-explanatory. But what, exactly, did the founders mean when they said a president could be removed from office for "misdemeanors"?

Digging through 18th-century law, Natelson found that misdemeanors, according to the lexicon of the day, meant a breach of trust. And breaching the public's trust could be as simple as performing negligently. Natelson notes that deciding whether a president was negligent could be influenced by political factors, but that ultimately political factors should not be decisive.

"Is there ambiguity?" Natelson says. "Yes. But fortunately, most cases are pretty much on one side or the other."

One objection to Originalism is that the Constitution is antiquated, that the people who wrote the document in the 18th century couldn't possibly have envisioned a world where "commerce" involves the Internet and a single "arm" can destroy a country.

"These are tough questions," Natelson says. "But no different from the sorts of questions that courts regularly deal with when they apply traditional rules to new events. The legitimacy of our government and public officials depends on the Constitution, which is the stated basis for our federal government. If the Constitution is not really law because the politicians or courts can change it whenever they want, then who is the president? Is there a president? How long will he serve? What are his powers?

"Any competent constitutional law professor can use 'living constitution' devices to manipulate the rules to show that we really don't have a constitutional president, or that he has virtually unlimited power, or that he can serve a life term," he says. "How do you know the contrary? Only because the Constitution – using the original meaning of the words – tells you." V

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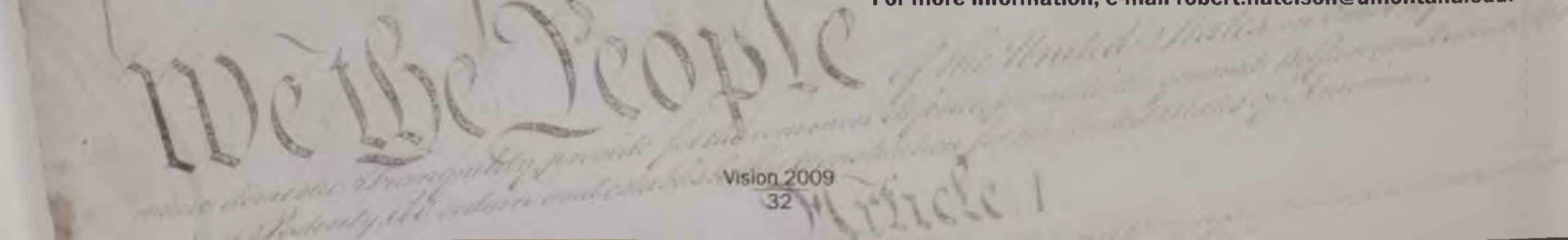

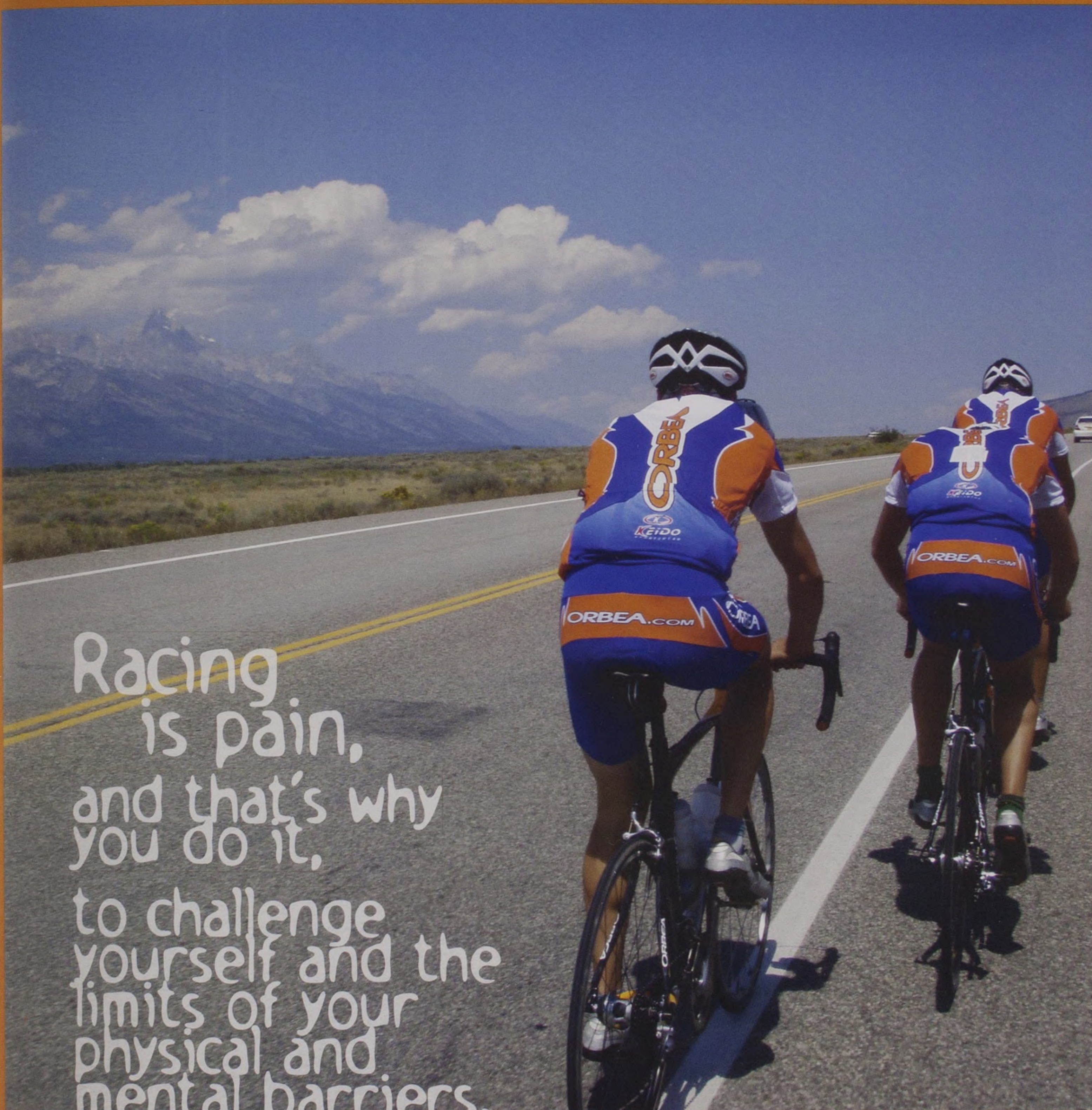

Photo of UM research subjects near Grand Teton National Park by Brent Ruby

Racing is pain, and that's why you do it, to challenge yourself and the limits of your physical and mental barriers. You don't experience that in an armchair watching television."

—MARK ALLEN
Six-time Ironman World Champion

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